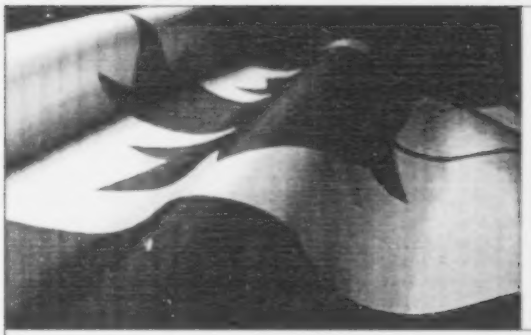

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Demographic Changes and Structural Shifts Towards Services, Implications for Productivity Growth in Canada

by

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Abstract

The relative size of services industries has increased in most industrialized countries in recent decades. In Canada, the value-added share of services in the economy has increased from about 55 per cent in the early 1960s to more than 70 per cent in the 1990s. Studies suggest that this reflects larger income elasticity for most services than for goods. Therefore, the relative size of the services sector will likely continue to grow in industrialized economies as real income increases. This trend towards services will probably be compounded by population ageing in industries such as health services. While productivity growth has improved in some services industries since the mid 1990s in some industrialized countries, including Canada, this is likely to exert a downward pressure on the aggregate productivity performance because productivity (level and growth) remains low in many services sectors.

The objective of this study is to assess the potential impact of these likely trends towards services on labour productivity growth in Canada. We find that shifts in consumption patterns arising from ageing could reduce Canada's labour productivity growth up to 2030 by less than 0.05 percentage points per year on average. This limited impact is mainly explained by the fact that the increased share of a low productivity service industry—health services—is to a large extent offset by the reduced share of another low productivity services industry—education. The negative impact on productivity is much larger when we assume that the historical trends towards services industries will continue, albeit at a lower pace, in the next decades. This would reduce aggregate annual productivity growth by about 0.15 percentage points up to 2015 and 0.25 percentage points between 2015 and 2030.

Résumé

La taille relative du secteur des services a augmenté dans la plupart des économies industrialisées au cours des dernières décennies. Au Canada, la part de la valeur ajoutée totale associée au secteur des services est passée de 55 pour cent au début des années 60 à 70 pour cent au cours des années 90. Certaines études suggèrent que cette tendance reflète une plus grande elasticité par rapport au revenu pour la plupart des services que des biens. Donc, la taille relative de ce secteur devrait continuer à augmenter au sein des pays industrialisés si le revenu réel continue à augmenter également. Cette tendance vers les services deviendra probablement encore plus importante sous l'influence du vieillissement de la population, en particulier pour certains services tels que les soins de la santé. Bien que la croissance de la productivité de certaines industries de services se soit améliorée depuis le milieu des années 90 dans certaines économies industrialisées, incluant le Canada, cette tendance vers les services devrait exercer une influence négative sur la productivité agrégée puisque la productivité (en termes de niveaux et de taux de croissance) demeure faible dans plusieurs secteurs des services.

L'objectif de cette étude est d'estimer l'impact potentiel de ces tendances vers les services sur la croissance de la productivité au Canada. Nous concluons que les changements dans la demande provenant du vieillissement de la population pourraient réduire la croissance de la productivité au Canada jusqu'en 2030 de moins de 0,05 points de pourcentage par année. Cet impact limité est principalement dû au fait que la plus grande importance d'une industrie des services à faible productivité, les soins de santé, est en grande partie contrebalancé par la part plus petite qu'occupera un autre secteur à faible productivité, l'éducation. L'impact négatif sur la productivité est beaucoup plus important si la tendance historique vers le secteur des services se poursuit au cours des prochaines décennies. Ceci réduirait la croissance annuelle de la productivité agrégée par environ 0.15 point de pourcentage jusqu'en 2015 puis de 0.25 point de pourcentage de 2015 à 2030.

1. Introduction

Population ageing is expected to have important economic and social effects. Many studies have explored its potential impact on the labour market (participation rates, labour force shortage, etc.). But few have looked at its potential impact on productivity. Of those that have, most have attempted to study the potential effect of ageing through its impact on capital deepening or worker's individual productivity, which is assumed to fall after a certain age.

The human capital literature has produced several models that generate the hump-shaped profile we observe in the wage data. Following the tradition of Mincer (1962) and Ben-Porath (1967), the standard human capital accumulation theory suggests that, as one ages, the present value of future net benefits linked to accumulating more human capital decreases. This produces a falling trend in human capital accumulation as an individual ages and slows down, if not decreases, his productivity. Some studies have looked at this pattern and have tried to extrapolate what could be the effect of ageing given this pattern of lifecycle productivity. Feyrer (2002) uses a panel data of OECD countries and regresses total factor productivity (TFP) on demographic variables. He finds a negative correlation between the proportion of the workforce in their fifties and sixties and TFP levels. Guillemette (2003) repeats this exercise but using time-series data for Canada. He also finds a negative but not statistically significant correlation between the proportion of older workers (older than 60) in the labour force and TFP. Exploiting variability in provincial data overtime, MacLeod and Tang (2004) examine the relationship between aggregate productivity growth and the share of older workers in the labour force. Their estimates suggest that the ageing of the labour force would reduce annual productivity growth in Canada by 0.2 to 0.3 percentage points in the next decade. These papers thus suggest a potential negative effect of ageing on productivity, through declining productivity of the ageing workforce.

However, the older members of our population are not simply workers: they are investors and consumers. A large body of the literature, starting with the seminal work of Feldstein (1974), has carefully studied the potential impact of ageing on aggregate savings and has projected a large decrease in investment and savings as population ages. This could have effects on productivity growth through shifts in capital intensity. In general, simulations from overlapping-generation models suggest that the demand for savings will fall faster than the supply thus generating a fall in the price of capital. At the same time, the relative scarcity of labour resulting from ageing exerts an upward pressure on wages. Therefore, an ageing population is expected to reduce the relative price of capital, increase the capital-labour ratio and hence increase labour productivity (Scarth (2002) and De Nardi et *al.* (1999)). Through the same channels, ageing also leads to human capital deepening in models with both overlapping generations and (human-capital driven) endogenous growth. (Fougère and Mérette (1998)).

Still, little is known about the potential role that the consumption patterns of an ageing population might have on productivity. One of the objectives of this paper is to investigate the potential effect of ageing consumers for Canada's productivity over the next 30 years. We hypothesize that an ageing population could lead to an increased use of low-productivity growth services such as health care, and this would

decrease aggregate labour productivity growth. Thus, this paper aims at exploring another channel that could be important in evaluating the overall impact of ageing on productivity growth.

However, the share of services in the economy would surely continue to increase even without population ageing. The long-standing increased importance of services industries in industrialized countries has been documented by many authors (for a survey of Canadian evidence, refer to Acharya (2003)). For a while, this appeared paradoxical given that the prices of services have normally increased faster than those of goods and suggested low demand price-elasticities. However, Möller (2001) and Appelbaum and Schettkat (1997) suggest that consumers are indeed responsive to relative price shifts, but that a strong income effect for services has led to the relative increased demand for services over time in industrialized countries. It is therefore likely that the share of services in the economy will continue to increase if real incomes continue to progress. In addition to income-related shifts in preferences, the importance of services could rise through continued increase in international trade. International specialization has led the production of many manufactured goods to be undertaken increasingly in less developed countries. This led industrialized nations' productive capacity to focus increasingly on services rather than goods and there is no reason to believe that this process will stop in coming decades. The continuation of these trends implies an increased importance of services industries in industrialized economies such as Canada in the future.

Population ageing and the continuation of the long-standing trend towards services are likely to have implications for Canada's aggregate productivity growth performance. While the overall Canadian service sector has significantly improved its productivity growth performance since 1997, this may still have negative implications for the aggregate productivity performance because many services industries continue to have low productivity levels (and often growth rates) than goods producing industries.

What will the ageing population consume and how might these new choices affect the industrial structure, and hence total economy productivity? How will long-standing trends towards services add to this effect? We assess first the potential impact of ageing on labour productivity growth by first estimating consumption by age and then analysing the effects of these age-induced changes in consumption patterns on the industrial structure and productivity using the input-output framework of the Canadian economy. We find that shifts in consumption patterns arising from ageing alone could reduce Canada's labour productivity level in 2030 by only about 1 per cent of the base-case productivity level. However, if we assume past structural trends towards services to continue in the future, the reduction in the productivity level reaches 5 per cent of the base-case.

These results are obviously sensitive to our assumptions regarding the rising share of services in the economy and their recent productivity growth. However, we have been fairly conservative in our assumptions; therefore, we view our estimated effect on productivity as lower bound estimates. Stronger trends towards services or larger shifts in elderly consumption towards personal services and health care would worsen these productivity prospects. Furthermore, a return to the low productivity growth experienced in most services industries before 1997 would substantially

compound the prospective negative productivity effects identify in this paper. In that respect, our analysis highlights the importance of maintaining high productivity growth rates in services industries for Canada's aggregate productivity performance.

Finally, we should stress that the objective of this study is to isolate the impact of changes in industrial composition originating from ageing and the continuation of long-standing trends towards services on Canadian labour productivity growth over the next 30 years or so. No attempt has been made to account for the other factors noted above—lower productivity of older workers and capital deepening.

We are aware of only one previous study that attempted such an exercise. Boersh-Supan (2002) uses data from Germany to estimate the future size of sectors given the current ageing patterns. He concludes that the shares in employment of 'health', 'personal outfit', 'energy' and 'housing' industries would increase while those of 'food, beverages, tobacco', 'other household goods', 'clothing and shoes', 'education and entertainment' and 'travel and communication' industries would fall. However, he does not explore the effect of these shifts on aggregate productivity.

The rest of the paper is organized as follows. Section 2 outlines the proposed methodology. We then present our results in section 3 followed by the conclusion in the fourth section. Finally, the potential caveats of the study are raised in the last section as well as suggestions for future research.

2. Methodology

We discuss in this section the approach used in this paper to estimate the potential effect of ageing and shifts in industry composition on productivity in Canada through three stages. We first highlight the general methodology linking shifts in industrial structure with productivity. We then explain in detail how we estimate consumption by age and finally, how we link changes in consumption patterns to modifications in the industrial structure.

Productivity is measured as real value-added per hour worked. Real value-added is measured by a chained-Fisher industry GDP index and hours worked are from Statistics Canada's Micro-Economic Analysis Division and available in Cansim Table 383-0010.

To analyze the impact of ageing and continued structural shifts towards services on productivity, a decomposition method for the Fisher index is useful. Lafortune (2004) shows that the Fisher index of aggregate labour productivity can be approximately decomposed by industry as follows:

$$\frac{LP_{t+1}}{LP_t} \approx \sum_{i=1}^{N} w_{i,t} \frac{h_{i,t+1}}{h_{i,t}} \frac{LP_{i,t+1}}{LP_{i,t}}, \qquad (1)$$

where $w_{i,t}$ is the nominal output share of industry i at time t, $h_{i,t}$, the share of hours worked and labour productivity is here defined by real output divided by hours

worked. In other words, the change in aggregate labour productivity between two consecutive years is a weighted sum of changes in sectoral labour productivity and changes in the shares of hours worked by industry. Aggregate labour productivity growth increases either because industry productivity growth increases or because of an increase in the share of high-productivity sectors.

In our framework, structural shifts towards services and ageing affect aggregate productivity growth enter through h_t and w_t given industry productivity growth rates, LP_t (baseline, 1997-20002 growth rates). In order to illustrate the role of structural shifts towards services and ageing, it is helpful to define, respectively, output[1] and hours worked per capita in each industry for each age group as:

$$c_{ikt} = \frac{y_{ikt}}{N_{kt}} \text{ and } l_{ikt} = \frac{H_{ikt}}{N_{kt}}, \tag{2}$$

where y_{ikt} is the nominal GDP of industry i produced for age group k and H_{ikt}, the number of hours worked in industry i for age group k and N_{kt} the population of age group k.

Assuming that each of the per capita terms grow at the same rate for each age group (but not necessarily for each industry), denoted a_t for value-added and b_t for hours, we can then compute output and hours worked of industry i at time $t+j$ as:

$$y_{i,t+j} = (a_t)^j \sum_{k=1}^{K} c_{ik,t} * N_{k,t+j} \tag{3}$$

$$\text{and } H_{i,t+j} = (b_t)^j \sum_{k=1}^{K} l_{ik,t} * N_{k,t+j} \tag{4}$$

Equations (3) and (4) can be re-expressed in terms of shares that could ultimately be used to estimate Equation (1):

$$w_{i,t+j} = \frac{(a_t)^j \sum_{k=1}^{K} c_{ik,t} * N_{k,t+j}}{\sum_{i=1}^{I} (a_t)^j \sum_{k=1}^{K} c_{ik,t} * N_{k,t+j}} \tag{5}$$

$$h_{i,t+j} = \frac{(b_t)^j \sum_{k=1}^{K} l_{ik,t} * N_{k,t+j}}{\sum_{i=1}^{I} (b_t)^j \sum_{k=1}^{K} l_{ik,t} * N_{k,t+j}} \tag{6}$$

[1] As mentioned early, productivity is defined as value added per hour worked.

a) Estimating the effect of structural shifts towards services on productivity growth

Again these two equations allow us to distinguish between structural shifts and ageing effects. If we were to look at the effect of structural shifts towards services alone, then, we could simply use:

$$w_{i,t+j} = \frac{(a_i)^j y_{i,t}}{\sum_{i=1}^{I} (a_i)^j y_{i,t}} \tag{7}$$

$$h_{i,t+j} = \frac{(b_i)^j H_{i,t}}{\sum_{i=1}^{I} (b_i)^j H_{i,t}}. \tag{8}$$

In order to analyze structural shifts towards services, we estimate the parameters a_i and b_i as to ensure that the trends in the shares of both nominal output and hours worked as expressed in Equations (7) and (8) match historical trends, based on a simple linear projection. Our projected industry shares of total economy nominal GDP and hours worked are presented, along with the actual data, in Figure 1. The difference between the projected shares and the actual shares in 1997-2002 shows the difference between short-term variations and longer-term trends. Recent data indicate a slowdown in the relative growth of the service sector and a stabilization, if not growth, in the manufacturing sector share. In contrast, long-term trends on which we rely clearly indicate a reduction in the relative size of the manufacturing sector and an increase in the relative size of the service sector.

Detailed results by industry are presented in Appendix A. It is clear from these figures and from Table 1 that our future trends are fairly conservative. Trends for fast-growing (professional, technical and scientific services; administrative and support services; FIRE) and medium-growth sectors (health care and social assistance; education, information and recreation) slowed down while downward future trends are not as large as those of previous periods. Since the Canadian population has changed dramatically in its demographic composition over the last 30 years, it is possible that our method for forecasting structural shifts already introduces some effects from demographic shifts and more particularly from ageing. We have attempted to control for that by estimating the structural shifts in the two key sectors (health and education) conservatively. We cannot, however, exclude the possibility that the structural trends identified here were linked to the coming of age of the baby-boom generation and that we are thus "double-counting" the demographic effect when superimposing both structural trends and ageing.

Figure 1: Median projected share of nominal GDP and hours by industry

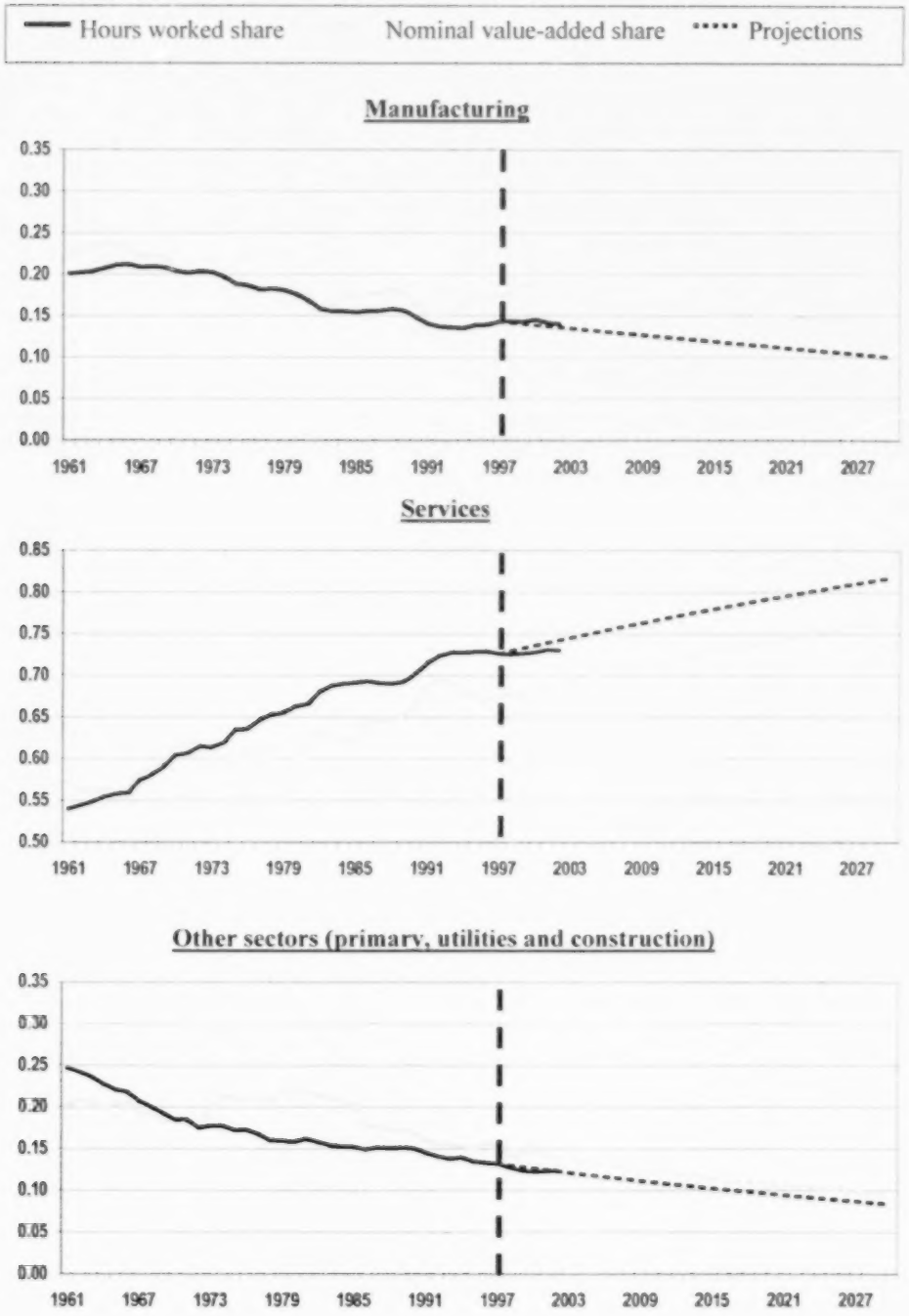

Table 1 : Historical and Projected Growth in Hours and Nominal GDP shares

	Nominal GDP		Hours	
	1962-1997	1998-2030	1962-1997	1998-2030
Primary industries	-1.27	-3.10	-2.73	-2.65
Utilities	0.98	0.46	0.37	-0.68
Construction	-0.97	-1.36	-0.68	-0.68
Trade	-0.37	-0.24	0.41	0.17
Transportation and warehousing	-0.96	-1.12	-0.53	-0.09
Information and recreation	0.43	0.23	N/A	1.20
FIRE	0.90	0.74	1.66	0.50
Professional, technical and scientific services	2.70	0.93	N/A	0.80
Administrative and support services	4.01	1.98	N/A	1.88
Education	1.25	-0.02	N/A	0.01
Health care and social assistance	1.71	1.03	N/A	0.31
Accommodation and food services	0.08	0.17	0.77	0.31
Other services	-0.45	0.17	N/A	-0.09
Public administration	-0.22	-0.02	N/A	-0.28

N/A: non-available before 1987.

b) Estimating consumption by age

If we want to look at the effect of ageing alone, we can do so by assuming that the growth of per capita elements is identical across industries. Then, Equations (5) and (6) can be simplified as follows:

$$w_{i,t+j} = \frac{\sum_{k=1}^{K} c_{ik,t} * N_{k,t+j}}{\sum_{i=1}^{I}\sum_{k=1}^{K} c_{ik,t} * N_{k,t+j}} \tag{9}$$

$$h_{i,t+j} = \frac{\sum_{k=1}^{K} l_{ik,t} * N_{k,t+j}}{\sum_{i=1}^{I}\sum_{k=1}^{K} l_{ik,t} * N_{k,t+j}} \tag{10}$$

As we have access to Statistics Canada's demographic projections, the only missing element of Equations (5) and (6) are the per capita production levels and per capita hours worked. How can we distribute the industry's aggregate by age? We first allocate final demand elements by age using estimated values provided by econometric projections from micro-level consumption data. Then, using Input-Output tables, we convert final demand shares into industry output shares by age group. These are explained in a greater detail below.

First, we estimate how consumption patterns differ by age for each personal consumption expenditure category included in the national accounts. As consumption is measured at the household level, we need to separate household consumption into

individual consumption by age group. We achieve this by estimating the following equation:

$$\frac{v_{ij}}{n_i} = \alpha_j + \beta_j n_i + \gamma_j \left(\frac{x_i}{n_i}\right) + \sum_{k=1}^{K-1} \delta_{jk} \left(\frac{n_{ik}}{n_i}\right) + \theta_j z_i + \varepsilon_{ij} \quad \text{for each good } j. \quad (13)$$

In this equation, v_{ij} represents the consumption level of household i for good j, $n_{ik}$the size of household i and for age group k, x_i a measure of either total consumption or total income of household i and z_i a vector of control variables including provincial and urban dummies and some other variables depending on the specifications.

Using the estimated coefficients, we then divide the consumption of each household by age. Thus, the consumption of household i for age group k is estimated by:

$$v_{ijk} = n_{ik}\left(\hat{\alpha}_j + \hat{\beta}_j n_i + \hat{\gamma}_j \left(\frac{x_i}{n_i}\right) + \hat{\delta}_{jk} + \hat{\theta}_j z_i\right) \quad (14)$$

This does not entirely isolate the effect of age from other factors such as income or household size. In this paper, we assume that these factors will evolve similarly for each age group over the period of analysis.

We first estimate Equation (13) for a variety of specifications. We estimate it using an ordinary least square model (OLS) controlling for income per capita. We first employ per capita consumption and per capita income. We also use decile dummies for both per capita consumption and per capita income. In addition, we introduce various additional variables including multigenerational household and institutionalized dummies, education levels and the number of workers.

Finally, we estimate a two-equation model, where we first estimate the probability of consuming a particular good by the household using a logit model. We then measure how large the expenditure will be using a simple OLS on the restricted sample, conditional on positive household expenditure on that good. Our predicted values then become:

$$v_{ijk} = \hat{P}(v_{ij} > 0) * n_{ik}\left(\hat{\alpha}_j + \hat{\beta}_j n_i + \hat{\gamma}_j \left(\frac{x_i}{n_i}\right) + \hat{\delta}_{jk} + \hat{\theta}_j z_i\right) \quad (15)$$

We justify the use of the two step methodology for a number of reasons. First, Manning *et al.* (1987), suggest that this two-step methodology might be more appropriate than the traditional Tobit II or Heckman model. Furthermore, Stata (1997) suggests that when the goal of an estimation exercise is to predict actual values rather than the latent variable, a two-step model is more appropriate. Finally, this methodology allows us to maintain linearity in the projections and thus additivity across households.

Because our goal is to match the expenditure categories and definitions of the National Accounts, we are extremely limited in our choice of datasets. The only micro-data source that could provide us with this type of information is the SPSD/M (1997 base-year) micro-simulation database provided by Statistics Canada (2001). It

has the advantage of categorizing private consumption identically as the National Accounts. Furthermore, the raw consumption data is also modified to better match the aggregate data from the National Accounts. It even includes elderly households in institutions or long-term care. It is not a standard source for consumption analysis since it is comprised of many "cloned" households and matched households from various surveys. However, we believe that it provides all the information required and that its drawbacks are not serious enough to compromise our results. To match National Accounts data, the amount spent on each category includes consumption taxes (federal and provincial). We also weigh each household by the weights provided in the dataset. A complete list of all personal expenditure categories and their description is included in Appendix B.

However, personal consumption makes up only around 55 per cent of total final demand. We have to rely on other methods to allocate the remaining final demand expenditures by age group. First, we use Health Canada (2003) to allocate government expenditures on health by age group[2]. The allocation of education expenditures by age is performed by using both enrollment rates by age and school type and total expenditures by school type, both from Statistics Canada (2000). Thus, overall, we allocate between 65 and 70 per cent of all final demand by age group according to these methods. The remaining sectors (investment, construction, inventories, international trade and other government expenditures) are allocated to each age group based on their share of total population.

c) Linking consumption to industrial structure

This subsection describes the methodology used in mapping final demand category by age, as explained above, to an industry output space using input-output square tables. First, we use a diagonal Make matrix to map final demand categories to an industry output space. Second, we use Input-Output square tables (Aggregation L level, 113 industries)[3] to allocate the industry output that is used as an intermediary input in another industry. Finally, we impose an industry's final demand output allocation by age unto each industry's intermediate input. For example, if the educational services industry were found, in the Final Demand table, to be consumed at 90 per cent by the young and only at 10 per cent by the older groups, we impose the same age structure across intermediate inputs used in the production of education services. This implicitly assumes that the type of inputs and their relative quantities used in the production process of each industry do not vary by age. We then obtain total output for each industry by age group by adding across all intermediate inputs (from the Use matrix) and final demand categories by age group (from the Final Demand matrix)[4].

Finally, the per capita output and hours worked are generated by imposing the shares by age group unto GDP and hours worked by industry provided by Statistics Canada and dividing them by age-group population. Thus, this methodology

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[2] Government expenditures correspond to two categories presented by Health Canada: provincial and territorial government health expenditures and other public sector health expenditures.

[3] As described above, imports and exports are simply divided as to give each age group equal per capita shares.

[4] The equilibrium of the input-output structure, which holds in 1997, will later be maintained in subsequent periods through international trade shifts.

implicitly assumes that the shares of nominal gross output by age correspond also to the shares of nominal value-added and hours worked. The industries that are not classified by NAICS were allocated in the following manner: the non-profit sector to other services, the universities to educational services, the hospitals to health care and social services, the other government services to public administration and the fictive industries to the industries that used in them, in proportion of their usage. Appendix C provides a two-industry, two-age group example to better illustrate the methodology.

Given our assumptions, this methodology allows us to estimate how industrial shares might evolve over the next 30 years. This is a very simplified model and various factors have been ignored. First, as we have noted above, we do not attempt to control for the potential capital deepening that may arise from ageing. Furthermore, this is a partial equilibrium exercise where we do not allow for the likely shift in investment from the goods to the service industries if demand for the later were to rise. Finally, we have here only explored the potential effect of shifts in domestic consumption pattern. If our projected increase in the demand for services is counterbalanced by an increase in the international demand for the goods we are producing, the projections we make would be inaccurate. Although these elements could have a significant impact, they are very difficult to quantify and model. We will thus abstract from them in this analysis.

3. Results: changes in the industrial structure

a) Estimating consumption patterns

Figure D1 of Appendix D presents our results and displays the share of each good consumed by age group in 1997. Each graph provides the range of estimates we obtain using our 11 different specifications by displaying the results in a box-and-whiskers plot. We first notice that our estimates do not vary greatly by specification except for a small group of commodities. These include: financial and legal services, educational and cultural services, domestic and child care services and hospital care and the like. The variability in these estimates appears to be linked to the use of income or total consumption as a control variable. We hypothesize that these goods are more sensitive to income and wealth than others. We also observe that most specifications do not modify our estimates of the consumption patterns of the elderly as contrasted to that of other age groups. This appears, once more, to be linked with the small difference between the older age groups' consumption and income as compared to younger consumers. We thus appear to be consistent in our estimates of the share of each good consumed by individuals aged 65 and above.

In order to judge the importance of age in consumption patterns, we compare the consumption share of each age group to their share in the 1997 population. In 1997, the age structure of the Canadian population was the following:

Table 2: Canadian population by age group, 1997

Age group	Percent of total population
0-5	7.78
6-14	12.20
15-24	13.50
25-34	15.49
35-44	17.05
45-54	13.13
55-64	8.63
65-74	7.05
75-84	3.98
85+	1.19

If each commodity were consumed by age group in proportion of their importance in the economy, ageing would have no effect on the demand patterns. In such an economy, young and old consumers would be interchangeable since this implies that they would have the same per capita consumption mix. Formally, Equations (9) and (10) state that if our per capita consumption elements are equal across age groups, nominal and hours worked shares will stay constant over time. However, this is not what we observe in our results. In Figure D1, we highlight each age group where the median of projected shares is at least 150 per cent of the population share. We can observe that young kids of age 0 to 5 increase the household demand for domestic and child care services, non-durable household supplies (which includes diapers), upholstery and furniture repairs and imputed rent. On the other hand, young adults between 15 and 24 years old consume a disproportionate amount of all educational and cultural services and paid rent. Young adults invest heavily in car-related products while elderly use various forms of public transportation. Detailed numbers are presented in Table D1.

Since we are particularly interested in the consumption pattern shifts that would occur when a growing number of middle-aged individuals become elderly, we focus on the shares consumed by the 45-54 years old to those by the 65 and above. Table 3 presents the top 10 commodities by age group. For each of these commodities, the difference between the median projected consumption share and the population share was at least 30 per cent for the middle-age group and at least 50 per cent for the elderly groups.

We observe, in Table 3, significant shifts in demand patterns. The working-age group owns a house as seen from the importance of imputed rent. It is still investing in durable goods such as household appliances and some semi-durables such as leather goods, furniture and recreation equipment. It consumes financial, legal and educational services. The elderly groups, on the other hand, only identify services as their top commodities, with the exception of pharmaceuticals. Their preferences are highly concentrated in medical goods and services, non-profit organizations, personal services and repairs. A large fraction of them are now renting (either independently or in nursing homes) rather than owning their own home, as seen from the appearance of paid rent in the two eldest groups. The importance of utilities (natural gas and other fuels), on the other hand, appears to remain throughout the age groups.

Table 3: Top 10 consumption categories (highest share consumed) by age group

	45-54	65-74	75-84	85+
1	Gross imputed rent	Hospital care and the like	Hospital care and the like	Hospital care and the like
2	Luggage, leather goods and other personal effects	Drugs and pharmaceutical products	Drugs and pharmaceutical products	Medical care
3	Financial and legal services	Operating expenses of non-profit organizations	Household equipment repairs	Gross paid rent
4	Alcoholic beverages bought in stores	Other fuels	Operating expenses of non-profit organizations	Other household services
5	Other fuels	Natural gas	Other household services	Drugs and pharmaceutical products
6	Education and cultural services	Upholstery and furniture repairs	Medical care	Upholstery and furniture repairs
7	Household appliances	Medical care	Gross paid rent	Natural gas
8	Furniture, carpets and other floor coverings	Household equipment repairs	Natural gas	Operating expenses of non-profit organizations
9	Recreation, sporting and camping equipment	Personal care services	Other fuels	Other fuels
10	Other auto related services	Purchased transportation	Personal care services	Personal care services

b) Linking consumption to industrial structure

Based on the results we obtained above, we divide 1997 industrial production by age group using the methodology described in section 3.

Figure D2 of Appendix D presents, in a similar format as Figure D1, the share of production of each industry allocated by age group. The industries are presented according to the nominal GDP size, from the biggest sector to the smallest. Once more, we highlight the industries for which the share of industry production captured by that good exceeds that of their relative importance in total population by more than 10 per cent. We find that younger consumers only capture a large fraction of the education industry. Young adults are particularly important for the arts and entertainment industry and the accommodation and restaurant establishments. We also find that sectors, such as public administration or construction, where most of the output is not consumed as personal expenditures, have age patterns that are almost identical to the shares in total population. Finally, the variations by age groups appear to be smaller for industry production than they were for consumption categories. Once more, median shares are presented in Table D2.

We again turn our attention to the 45-54 and the elderly. Table 4 presents the top five industries for each age group. For each industry, the share allocated to each age group is at least 110 per cent of its population share. Once more, the comparison is striking. Our working-age adults are important consumers for accommodation and food services, recreation, cultural and the financial services industries. On the other hand, the elderly age groups are targeted consumers for a consistent group of industries: health care, utilities and other services (which include the non-profit sector). The importance of administrative and support services for the elderly stems

from their consumption of two services: household services and public transportation. Thus, as our population age, we appear to observe that their demand for goods produced by the recreation industries diminishes and is replaced by a high reliance on health care, support services, non-profit sector and utilities.

Table 4: Top five industries (highest share) by age group

	45-54	65-74	75-84	85+
1	Accommodation and food services	Health care services and social assistance	Health care services and social assistance	Health care services and social assistance
2	Arts, entertainment and recreation	Other services	Other services	Other services
3	FIRE and management of companies	Utilities	Utilities	Administrative and support services
4	Information and cultural industries	Arts, entertainment and recreation	Administrative and support services	Utilities
5	Manufacturing	Retail trade	Information and cultural industries	Information and cultural industries

What is the effect of these patterns on future industry composition? Hours and nominal value-added shares by industry for our base year, 1997, and two projected years, 2015 and 2030, are presented in Table 5. The table presents only the median result since we observe only small differences between each of our specifications. If no other structural change were to occur, these results suggest that ageing will have a fairly limited impact on the industrial structure. The only sectors where we observe a large impact are, not surprisingly, health, where the share increases, and education, where the share falls. Construction, public administration, non-mining primary and FIRE will see their shares decrease after 1997. On the other hand, other services; administrative and support services and manufacturing are likely to increase their shares of the economy with ageing. Hours and value-added shares in other sectors would remain more or less stable.

However, it would be simplistic to assume that the only driver of structural change in the future is ageing. We should also consider the effects of some long-standing trends towards a more service-oriented economy. Table 6 presents shares of hours worked and nominal value-added by industry for 1997, 2015 and 2030 if we exclude ageing and only focus on the effect of trends towards services, as presented in Equations (7) and (8). This time, the differences are more striking. All goods-producing sectors would have falling shares of total hours worked and nominal output (except utilities). On the other hand, some services industries would become more important. The share of hours worked would increase significantly in retail, FIRE, professional, scientific and technical services, administrative and support services and information and cultural industries. FIRE's nominal output would rise much faster than its labour input: this would most likely represent the increase in the value of owner-occupied dwellings. In addition to the financial sector, the nominal output share of health care, professional, scientific and technical services and administrative services would increase notably. That of transport and warehousing would fall significantly. Shares in other sectors would stay more or less stable.

Finally, we also include a scenario where the effect of ageing is coupled with that of trend structural shifts towards services. We find, as displayed in Table 7, that the two phenomena are often reinforcing each other. First, health care increases its share much more importantly than when ageing was excluded and education services fall much more rapidly. The shrinking sectors are decreasing their shares more rapidly with the addition of ageing. The shares of hours worked and nominal output of construction, manufacturing, agriculture and transport and storage are even lower once we introduce consumption shifts due to ageing. Similarly, the positive trends for administrative and information services are strengthened by ageing. On the other hand, some growing sectors such as FIRE, retail trade, and professional, scientific and technical services see their growing trend tampered by the introduction of consumption patterns due to ageing. Overall, the introduction of ageing affects mostly two key sectors: health and education. Its effect on other sectors remains small compared to that which would result from the continuation of historical trends towards services.

Table 5: Median shares of hours and nominal value-added by industry, effect of ageing alone

	1997	2015	2030	Change 1997-2015	Change 2015-2030
Hours worked					
Agriculture, forestry, fishing and hunting	4.39	4.31	4.26	-0.08	-0.05
Mining and oil and gas extraction	1.33	1.33	1.31	0.00	-0.02
Utilities	0.78	0.79	0.80	0.01	0.01
Construction	6.64	6.53	6.44	-0.11	-0.09
Manufacturing	14.27	14.41	14.31	0.14	-0.10
Wholesale	5.98	6.00	5.96	0.02	-0.04
Retail	10.32	10.40	10.32	0.08	-0.08
Transportation and warehousing	5.28	5.25	5.22	-0.03	-0.03
Information and cultural industries	2.16	2.19	2.18	0.03	-0.01
FIRE+	7.17	7.19	7.10	0.02	-0.09
Professional, scientific and technical services	5.17	5.18	5.15	0.01	-0.03
Administrative and support services	3.20	3.22	3.21	0.02	-0.01
Education services	6.01	5.10	4.64	-0.91	-0.46
Health care and social assistance	8.61	9.36	10.34	0.75	0.98
Accommodation and food services	6.51	6.55	6.47	0.04	-0.08
Arts, entertainment and recreation	1.48	1.51	1.51	0.03	0.00
Other services	5.46	5.58	5.70	0.12	0.12
Public administration	5.22	5.13	5.08	-0.09	-0.05
Nominal value-added					
Agriculture, forestry, fishing and hunting	2.50	2.46	2.44	-0.04	-0.02
Mining and oil and gas extraction	4.15	4.14	4.11	-0.01	-0.03
Utilities	3.27	3.31	3.34	0.04	0.03
Construction	5.26	5.18	5.13	-0.08	-0.05
Manufacturing	17.42	17.62	17.54	0.20	-0.08
Wholesale	5.35	5.37	5.35	0.02	-0.02
Retail	5.17	5.22	5.20	0.05	-0.02
Transportation and warehousing	4.94	4.92	4.90	-0.02	-0.02
Information and cultural industries	3.43	3.47	3.47	0.04	0.00
FIRE+	19.72	19.79	19.62	0.07	-0.17
Professional, scientific and technical services	3.71	3.71	3.70	0.00	-0.01
Administrative and support services	1.88	1.90	1.90	0.02	0.00
Health care and social assistance	6.29	6.85	7.59	0.56	0.74
Education services	5.18	4.40	4.01	-0.78	-0.39
Accommodation and food services	2.41	2.42	2.40	0.01	-0.02
Arts, entertainment and recreation	0.91	0.93	0.93	0.02	0.00
Other services	2.35	2.40	2.46	0.05	0.06
Public administration	6.06	5.97	5.92	-0.09	-0.05

Table 6: Median shares of hours and nominal value-added by industry, effect of structural trends alone

	1997	2015	2030	Change 1997-2015	Change 2015-2030
Hours worked					
Agriculture, forestry, fishing and hunting	4.39	2.84	1.93	-1.55	-0.91
Mining and oil and gas extraction	1.33	0.72	0.42	-0.61	-0.30
Utilities	0.78	0.70	0.63	-0.08	-0.07
Construction	6.64	5.94	5.31	-0.70	-0.63
Manufacturing	14.27	11.88	10.00	-2.39	1.88
Wholesale	5.98	5.95	5.81	-0.03	-0.14
Retail	10.32	11.03	11.42	0.71	0.39
Transportation and warehousing	5.28	5.26	5.13	-0.02	-0.13
Information and cultural industries	2.16	3.11	4.13	0.95	1.02
FIRE+	7.17	7.93	8.46	0.76	0.53
Professional, scientific and technical services	5.17	6.04	6.73	0.87	0.69
Administrative and support services	3.20	4.52	5.92	1.32	1.40
Health care and social assistance	8.61	9.20	9.53	0.59	0.33
Education services	6.01	6.09	6.04	0.08	-0.05
Accommodation and food services	6.51	6.96	7.21	0.45	0.25
Arts, entertainment and recreation	1.48	1.38	1.27	-0.10	-0.11
Other services	5.46	5.44	5.31	-0.02	-0.13
Public administration	5.22	5.01	4.75	-0.21	-0.26
Nominal value-added					
Agriculture, forestry, fishing and hunting	2.50	0.97	0.43	-1.53	-0.54
Mining and oil and gas extraction	4.15	2.77	1.92	-1.38	-0.85
Utilities	3.27	3.60	3.80	0.33	0.20
Construction	5.26	4.18	3.36	-1.08	-0.82
Manufacturing	17.42	15.60	13.87	-1.82	-1.73
Wholesale	5.35	5.50	5.48	0.15	-0.02
Retail	5.17	4.71	4.25	-0.46	-0.46
Transportation and warehousing	4.94	4.09	3.41	-0.85	-0.68
Information and cultural industries	3.43	3.46	3.40	0.03	-0.06
FIRE+	19.72	22.84	25.16	3.12	2.32
Professional, scientific and technical services	3.71	4.45	5.04	0.74	0.59
Administrative and support services	1.88	2.72	3.60	0.84	0.88
Education services	5.18	5.23	5.14	0.05	-0.09
Health care and social assistance	6.29	7.67	8.82	1.38	1.15
Accommodation and food services	2.41	2.52	2.54	0.11	0.02
Arts, entertainment and recreation	0.91	1.11	1.27	0.20	0.16
Other services	2.35	2.46	2.49	0.11	0.03
Public administration	6.06	6.12	6.02	0.06	-0.10

Table 7: Median shares of hours and nominal value-added by industry, effect of ageing and structural trends towards services

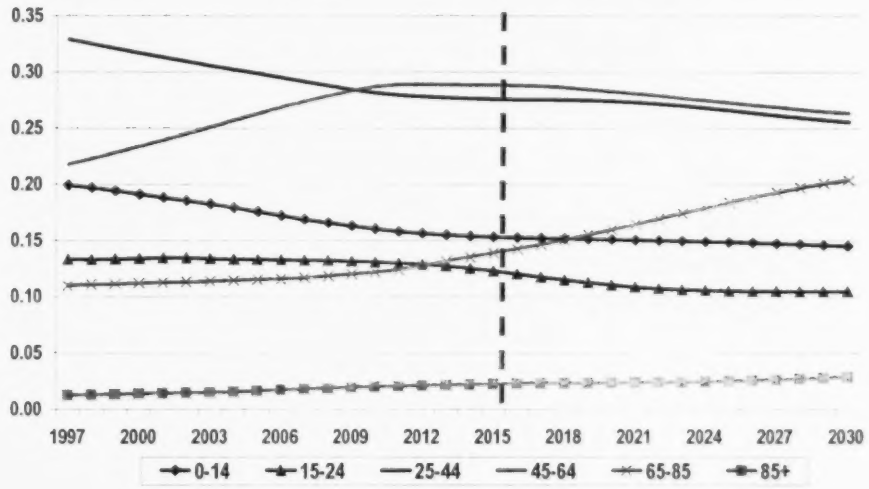
	1997	2015	2030	Change 1997-2015	Change 2015-2030
Hours worked					
Agriculture, forestry, fishing and hunting	4.39	2.79	1.87	-1.60	-0.92
Mining and oil and gas extraction	1.33	0.71	0.41	-0.62	-0.30
Utilities	0.78	0.71	0.64	-0.07	-0.07
Construction	6.64	5.83	5.13	-0.81	-0.70
Manufacturing	14.27	11.99	9.99	-2.28	-2.00
Wholesale	5.98	5.97	5.77	-0.01	-0.20
Retail	10.32	11.10	11.39	1.22	0.29
Transportation and warehousing	5.28	5.22	5.06	-0.06	-0.16
Information and cultural industries	2.16	3.15	4.16	0.99	1.01
FIRE+	7.17	7.95	8.36	0.78	0.41
Professional, scientific and technical services	5.17	6.04	6.68	0.87	0.64
Administrative and support services	3.20	4.54	5.93	1.34	1.39
Education services	6.01	5.16	4.64	-0.85	-0.52
Health care and social assistance	8.61	9.99	11.41	1.38	1.42
Accommodation and food services	6.51	7.00	7.14	0.49	0.14
Arts, entertainment and recreation	1.48	1.41	1.29	-0.07	-0.12
Other services	5.46	5.55	5.52	0.09	-0.03
Public administration	5.22	4.93	4.61	-0.29	-0.32
Nominal value-added					
Agriculture, forestry, fishing and hunting	2.50	0.96	0.42	-1.54	-0.54
Mining and oil and gas extraction	4.15	2.75	1.89	-1.40	-0.86
Utilities	3.27	3.64	3.85	0.37	0.21
Construction	5.26	4.10	3.25	-1.16	-0.85
Manufacturing	17.42	15.76	13.87	-1.66	-1.89
Wholesale	5.35	5.51	5.45	0.17	-0.06
Retail	5.17	4.74	4.24	-0.43	-0.50
Transportation and warehousing	4.94	4.07	3.36	-0.87	-0.71
Information and cultural industries	3.43	3.50	3.42	0.07	-0.08
FIRE+	19.72	22.89	24.88	3.17	1.99
Professional, scientific and technical services	3.71	4.44	5.00	0.73	0.56
Administrative and support services	1.88	2.73	3.61	0.85	0.88
Education services	5.18	4.44	3.96	-0.74	-0.48
Health care and social assistance	6.29	8.34	10.56	2.05	2.22
Accommodation and food services	2.41	2.53	2.52	0.12	-0.01
Arts, entertainment and recreation	0.91	1.13	1.29	0.22	0.16
Other services	2.35	2.51	2.59	0.16	0.08
Public administration	6.06	6.02	5.84	-0.04	-0.18

4. Results: labour productivity effect

As highlighted before, the industry composition effects of ageing are small, which suggests a limited impact on productivity growth. Nevertheless, we also observe fairly large effects once we introduce long-standing structural trends towards services. What will be the effect of these ageing and service-oriented structural shifts on aggregate productivity level and growth?

We have here divided our projection exercise into two distinct periods: 1998-2015 and 2016-2030. Figure 2 motivates the choice of these sub-periods. The projected proportion of each age group in total population against time suggests that ageing will have two distinct phases in Canada. Before 2015, we observe mostly a decrease in the young (0-24) and prime-aged groups coupled with an increase in the pre-retirement cohort (45-64). After 2015, the share of retired individuals (65-84) increases significantly, at the expense of the young, prime-aged and pre-retired cohorts. As shown earlier, consumption patterns do not change uniformly with age. In particular, we do not necessarily observe large variations in consumption patterns of adult groups of different age but we see clear differences between pre-retired and elderly individuals. Thus, we might expect the estimated productivity effect of ageing to be smaller in the first period than in the second.

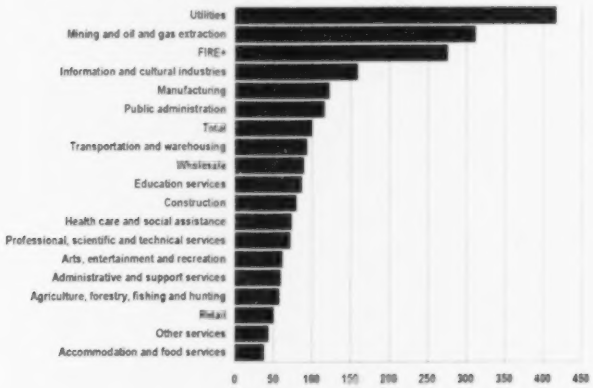
Figure 2: Forecasted age structure of the Canadian population, 1997-2030



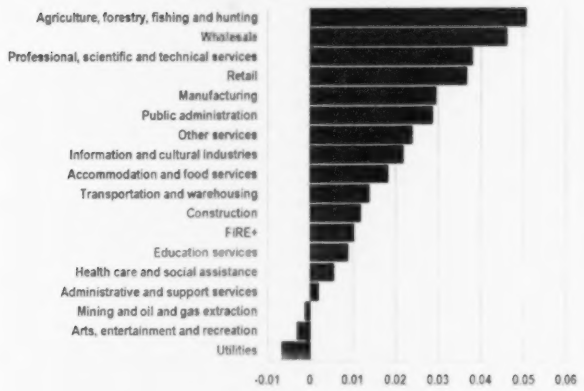
Changes in Canada's industrial structure may have two distinct effects on aggregate labour productivity. If these shifts tend to favour industries that have low productivity *levels*, we can expect aggregate productivity to fall. We will refer to this as a "level effect". But these shifts might also increase the importance of sectors with low productivity *growth* rates. This shift would also decrease aggregate productivity growth. We will refer to these as "growth effects". These effects might also be very different for a given sector. Figure 3 identifies the low-level and low-growth performers in terms of labour productivity. We see that some structural changes can have two opposing effect: for example, an increase in the size of the utilities sector would reduce productivity growth because of its poor growth performance but would

also increase the productivity growth given its high productivity level. We will thus explore these two effects separately in the following sections.[5]

Figure 3: Labour Productivity by Industry
1997 Level (Total economy=100)



1998-2002 Growth rates



[5] A caveat to the following analysis should be added. It is now accepted that our traditional measure of productivity (real output per hours) suffers from measurement problems, in particular in the service sectors. If productivity growth of some of the key sectors identified here (such as health and education) is understated, our conclusions could be greatly altered.

a) Identifying the level effects of ageing and structural shifts towards services on labour productivity

Reallocating resources to sectors that are more or less productive should have an impact on aggregate productivity. However, this intuitive result is very hard to translate in the context of a Fisher-indexed output. This is because the aggregation in a Fisher world must take care of shifts in both nominal and hours shares. In order to show this property of Fisher-based productivity indexes we start by considering the impact of a changing industrial structure when there is no productivity growth.

Let us assume a world where there is no labour productivity growth within industries. Using (1), aggregate labour productivity for year $t+j$ is equal to:

$$LP_{t+j} = LP_{t+j-1} \sum_{i=1}^{I} w_{i,t+j-1} \frac{h_{i,t+j}}{h_{i,t+j-1}} \tag{16}$$

Since, for all years, labour productivity levels by industry are identical, we can introduce levels such that:

$$LP_{t+j} = LP_{t+j-1} \sum_{i=1}^{I} w_{i,t+j-1} \frac{\dfrac{h_{i,t+j}}{H_{i,t+j-1}}}{H_{t+j-1}} \left(\frac{LP_i * H_{i,t+j-1}}{Y_{i,t+j-1}} \right) \tag{17}$$

Then, simplifying and rearranging yields:

$$LP_{t+j} = LP_{t+j-1} \sum_{i=1}^{I} w_{i,t+j-1} \frac{H_{t+j-1}}{Y_{i,t+j-1}} \left(LP_i * h_{i,t+j} \right) \tag{18}$$

$$LP_{t+j} = \sum_{i=1}^{I} \left(w_{i,t+j-1} \frac{Y_{t+j-1}}{Y_{i,t+j-1}} \right) \left(LP_i * h_{i,t+j} \right) \tag{19}$$

Thus, in a Fisher-indexed world without labour productivity growth within industries, future labour productivity does not exactly correspond to future hours multiplied by current labour productivity levels. In addition to this, we must take into account the variations in output prices. Specifically, the Laspeyres result is now multiplied by the ratio of nominal GDP share to real GDP share for each industry.

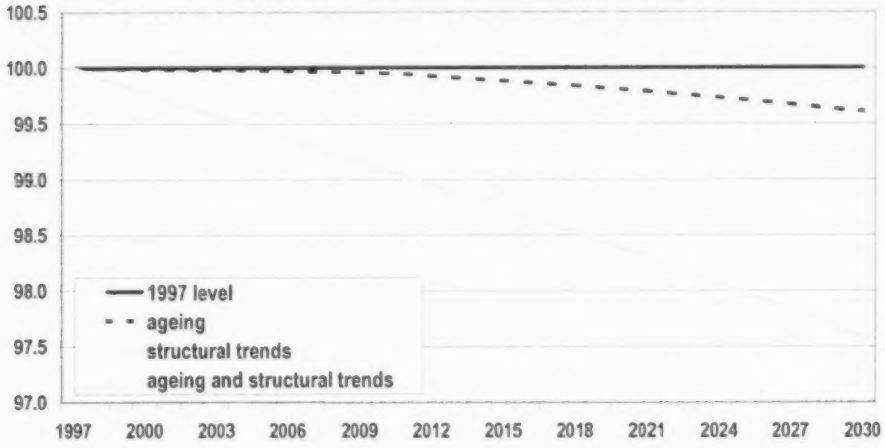
Specifically, the impact of structural shift imposed in our scenarios (S) as compared to the no growth base-case (B) will be measured as:

$$\dot{LP}_t^S - \dot{LP}_t^B = \sum_{i=1}^{I} \left(w_{i,t-1}^S \frac{h_{i,t}^S}{h_{i,t-1}^S} - w_{i,t-1}^B \right) \tag{20}$$

What would happen to aggregate labour productivity if the industrial structure changes as presented above without any productivity growth at the industry level? In other words, what would be the implication for aggregate productivity of imposing the expected changes in the industrial structure on today's industry productivity levels? Figure 4 presents the results we obtained for our three scenarios. In all three cases, we expect the labour productivity level to decrease and labour productivity

growth to become negative. The effect of ageing[6], however, is small, reducing the 2030 labour productivity level by a mere 0.4 per cent. This is a surprising result given that we expect a low productivity sector, health care, to expand over this period. However, this limited effect depends greatly on the reduction in size of another low-productivity sector, education. If we introduce structural trends towards services, the effect becomes much larger and now corresponds to a fall of more than 2.4 per cent from the initial level. When we combine both effects, the level of labour productivity is reduced to around 2.7 per cent in 2030[7].

Figure 4: Level effect on labour productivity



b) Identifying the growth effect of ageing and structural changes towards services on labour productivity

However, we do not expect a scenario where there will be no productivity growth in each industry. How can we introduce productivity growth by industry in this framework and measure its interaction with ageing and service-related structural changes? In our current dynamic framework, the previous hypothesis is equivalent to measuring productivity if the industrial structure were to change but not the *relative* labour productivity of each industry. We arrive at this by imposing a uniform rate of productivity growth to each industry and modifying only the industrial structure. This effect, denoted "structure effect", is roughly equal to the level effect presented above[8]. Yet, we also need to introduce the "growth" effect we explained earlier. This will simply consist in comparing the effect of this new structure under a scenario where all sectors grow at the same rate with one where productivity growth by industry varies. This would imply that productivity growth would increase if some

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[6] The effect of ageing is here modeled according to the consumption predictions obtained from the OLS specification controlling for total consumption. However, we obtain very similar results with the other specifications.

[7] The effects of ageing and structural shifts taken separately do not exactly add up to their combined effect due to interaction between the two phenomena.

[8] Formally, Equation (20)'s level effect is comparable to the structure effect: $\sum_{i=1}^{I}\left(w_{i,t-1}^{S}\frac{h_{i,t+1}^{S}}{h_{i,t}^{S}}-w_{t}^{B}\right)\left(LP_{t-1}^{B}\right)$.

The difference is small and less than 0.002 percentage points per year for all specifications.

sectors with high-productivity growth have increasing shares in the economy or vice versa. We will refer to this as a "productivity effect".

In order to separate these effects, we will need to compare our scenarios to a base-case with particular characteristics. To obtain this base-case, we used a simplified version of Equation (1) which becomes, because we have no change in hours:

$$\frac{LP_{i,t+1}^{B}}{LP_{i,t}^{B}} = \frac{LP_{t+1}^{B}}{LP_{t}^{B}} = \sum_{i=1}^{N} \left(w_{i,t}^{1997-2000}\right)\left(\frac{LP_{i,t+1}^{1997-2002}}{LP_{i,t}^{1997-2002}}\right) \qquad (21)$$

Our nominal shares are here the average of 1997-2000 and the industry productivity growth, the average rate of 1997-2002. We thus establish a base-case where the nominal shares are those of the average of 1997-2000 and the productivity growth of each industry is uniformly equal to our baseline growth rate as obtained from Equation (21). Thus, our base-case not only has constant nominal and hours shares but also maintains the differences in relative productivity level between industries as observed on average over the 1997-2002 period.

We then generate scenarios that impose two distinct shocks. First, we modify the Canadian industrial structure. Because each industry differs in its relative productivity level, this will generate the "structure effect". However, our scenarios also impose different productivity growth by industries. Thus, the new structure also has a growth effect because it will favour sectors with high or low productivity growth. This represents our "productivity effect". Without any structural change, however, these varying productivity growth rates would generate the same aggregate productivity growth rate as the base-case.

Formally, we decompose productivity growth rate differences between each scenario (S) and the base-case (B) in the following fashion:

$$\dot{LP}_{t}^{S} - \dot{LP}_{t}^{B} = \sum_{i=1}^{I} w_{i,t}^{S} \frac{h_{i,t+1}^{S}}{h_{i,t}^{S}} \left(\dot{LP}_{i,t}^{S} - \dot{LP}^{B}\right) + \sum_{i=1}^{I} \left(w_{i,t-1}^{S} \frac{h_{i,t+1}^{S}}{h_{i,t}^{S}} - w_{t}^{B} \right) \left(\dot{LP}^{B} + 1\right) \qquad (22)$$

The first term in this equation represents the "productivity effect" of each industry. It presents the effect on productivity growth of having differential growth among industries, given future shares. We present each separately. The industries for which this contribution is positive represent sectors where productivity growth is above the average and vice versa. The second term represents the "structure effect" and we will only present its sum. It represents the effect of changing structure where all industries have the same growth rate. As explained above, it closely matches the level effect presented above, but now imposed on a growing base-case.

Although the "structure effect" does not introduce individual productivity levels explicitly, it includes level effects implicitly since we can rewrite it, based on Equation (17), as:

$$\sum_{i=1}^{I}\left(w_{i,t-1}^{S}\frac{h_{i,t+1}^{S}}{h_{i,t}^{S}}-w_{i}^{B}\right)\left(\dot{LP}^{B}+1\right)=\left(\frac{\sum_{i=1}^{I}\left(w_{i,t+j-1}^{S}\frac{Y_{t+j-1}^{S}}{Y_{i,t+j-1}^{S}}\right)\left(LP_{i}*h_{i,t+j}^{S}\right)}{LP_{t+j-1}^{S}}-1\right)\left(\dot{LP}^{B}+1\right) \quad (23)$$

$$\sum_{i=1}^{I}\left(w_{i,t-1}^{S}\frac{h_{i,t+1}^{S}}{h_{i,t}^{S}}-w_{i}^{B}\right)\left(\dot{LP}^{B}+1\right)=\left(\frac{\sum_{i=1}^{I}\left(w_{i,t+j-1}^{S}\frac{Y_{t+j-1}^{S}}{Y_{i,t+j-1}^{S}}\right)\left(LP_{i}*h_{i,t+j}^{S}\right)-\sum_{i=1}^{I}\left(w_{i,t+j-2}^{S}\frac{Y_{t+j-2}^{S}}{Y_{i,t+j-2}^{S}}\right)\left(LP_{i}*h_{i,t+j-1}^{S}\right)}{LP_{t+j-1}^{S}}\right)\left(\dot{LP}^{B}+1\right) \quad (24)$$

$$\sum_{i=1}^{I}\left(w_{i,t-1}^{S}\frac{h_{i,t+1}^{S}}{h_{i,t}^{S}}-w_{i}^{B}\right)\left(\dot{LP}^{B}+1\right)=\left(\frac{\sum_{i=1}^{I}LP_{i}\left(\left(h_{i,t+j}^{S}\right)\left(w_{i,t+j-1}^{S}\frac{Y_{t+j-1}^{S}}{Y_{i,t+j-1}^{S}}\right)-\left(h_{i,t+j-1}^{S}\right)\left(w_{i,t+j-2}^{S}\frac{Y_{t+j-2}^{S}}{Y_{i,t+j-2}^{S}}\right)\right)}{LP_{t+j-1}^{S}}\right)\left(\dot{LP}^{B}+1\right) \quad (25)$$

Thus, a sector's "structure effect" will be larger if it has a larger productivity level and the sign will depend on the growth of hours, nominal and real output shares.

Our baseline average annual productivity growth, given by Equation (21) is 1.975 per cent, which is somewhat lower than the actual average labour productivity growth over this period because of unaccounted structural shifts. It also corresponds to the fixed productivity growth rate of each industry in our base-case. What will then be the effect of ageing and structural trends on this growth rate? What will cause the difference? Which industries will be mostly responsible for these changes?

First, if we only impose the structural shifts due to ageing, the effect on aggregate labour productivity growth is negative and small. We find that our aggregate growth rate is reduced to 1.95 per cent over 1998-2015 and to 1.93 over the 2016-2030 period. This translates into a productivity level gap of around 1 per cent of the base-case level in 2030. This is 0.6 percentage points above the level effect identified above because some of the changes in structure favour low productivity-growth sectors. Table 8 presents the productivity growth decomposition of this scenario. In the two periods, the structure effect is very small. This is due to the fact that, as explained above, an increase in one low-productivity sector (health care) is partially offset by the reduction in the importance of another one (education). To evaluate the contribution of each industry to the productivity effect, we compare them to that of a hypothetical situation where there would be no shift in structure but differential growth rates (we will refer to this as "comparison state"). This allows us to identify the effect of changes in structure on the productivity effect. The comparison state has no aggregate productivity effect: any deviation from it is thus what drives our gap. We thus present deviations from the comparison state for each period. From this, we can see that four key sectors generate the negative productivity effect we observe. The increase in the demand for utilities and health care (two low productivity-growth sectors) and the diminished usage of two high productivity-growth sectors (professional services and manufacturing) are driving the productivity

effect down. In particular, the contribution of health care increases over the period as this low productivity growth sector increases its share in the economy.

Table 8: Labour productivity growth decomposition: effect of ageing

	Comparison state	1998-2015	2016-2030
Productivity effect			
Agriculture, forestry, fishing and hunting	0.076	0.000	0.000
Mining and oil and gas extraction	-0.091	0.004	0.005
Utilities	-0.079	-0.008	-0.009
Construction	-0.041	0.000	0.000
Manufacturing	0.178	-0.007	-0.007
Wholesale	0.139	0.003	0.003
Retail	0.089	0.001	0.001
Transportation and warehousing	-0.029	0.000	0.000
Information and cultural industries	0.007	0.000	0.000
FIRE+	-0.185	-0.004	-0.004
Professional, scientific and technical services	0.074	-0.006	-0.006
Administrative and support services	-0.035	0.0001	0.001
Education services	-0.054	0.002	0.009
Health care and social assistance	-0.087	-0.005	-0.015
Arts, entertainment and recreation	-0.020	-0.001	-0.001
Accommodation and food services	-0.004	0.000	0.000
Other services	0.010	0.000	0.000
Public administration	0.052	0.001	0.001
Total productivity effect	0	-0.020	-0.023
Structure effect	0	-0.007	-0.019
Total growth gap	0	-0.027	-0.042
Addendum. Difference with base-case level (%)		*2015*	*2030*
Productivity effect		*-0.35*	*-0.69*
Structure effect		*-0.12*	*-0.39*
Total effect		*-0.47*	*-1.08*

If we include the trend shifts towards services, the prognostic is somber with growth rates of 1.84 per cent for the 1998-2015 period and 1.75 per cent for 2016-2030. This translates into a productivity level deficit in 2030 of around 5.5 per cent. We repeat our decomposition exercise with this new scenario in Table 9. The structure effect is negative and larger than before. This is due in particular to the reduction in size of high-productivity level sectors such as manufacturing, agriculture and mining. The productivity effects are also larger than in Table 8 although in a smaller proportion of the entire gap for the first period. Once more, we use our comparison state to judge the importance of each sector's contribution to the productivity effect. We find here that the lower expected demand for primary industries and manufacturing (high-productivity growth sectors) contributes significantly to the lower productivity growth. Similarly, the increased use of low-productivity growth sectors such as FIRE, administrative and support services and health care also reduces aggregate productivity growth. Four sectors significantly counterbalance this effect: the decreased importance of mining and construction reduces the effect of these low productivity growth sectors while the increased share

of professional, scientific and technical services and wholesale, with a high productivity-growth performance improves its positive productivity contribution.[9]

Table 9: Labour productivity growth decomposition: effect of structural trends towards services

	Comparison state	1998-2015	2016-2030
Productivity effect			
Agriculture, forestry, fishing and hunting	0.076	-0.026	-0.055
Mining and oil and gas extraction	-0.091	0.021	0.044
Utilities	-0.079	-0.011	-0.018
Construction	-0.041	0.004	0.011
Manufacturing	0.178	-0.018	-0.036
Wholesale	0.139	0.005	0.006
Retail	0.089	-0.004	-0.012
Transportation and warehousing	-0.029	0.002	0.007
Information and cultural industries	0.007	0.000	0.000
FIRE+	-0.185	-0.019	-0.045
Professional, scientific and technical services	0.074	0.001	0.013
Administrative and support services	-0.035	-0.007	-0.021
Education services	-0.054	-0.003	-0.003
Health care and social assistance	-0.087	-0.011	-0.029
Arts, entertainment and recreation	-0.020	-0.003	-0.007
Accommodation and food services	-0.004	0.000	0.000
Other services	0.010	0.000	0.000
Public administration	0.052	0.002	0.002
Total productivity effect	0	-0.066	-0.142
Structure effect	0	-0.071	-0.080
Total growth gap	0	-0.137	-0.223
Addendum: Difference with base-case level (%)		*2015*	*2030*
Productivity effect		*-1.15*	*-3.20*
Structure effect		*-1.25*	*-2.41*
Total effect		*-2.40*	*-5.61*

Finally, we also combine ageing and structural trends to establish their joint effect.[10] Ageing here deteriorates our growth rate even further. Productivity growth rates now fall to around 1.83 per cent over 1998-2015 and 1.73 per cent for 2016-2030. Our 2030 productivity level gap with the base-case is now around 6 per cent. The decomposition results are presented in Table 10. We can first observe that the productivity effects are similar but the structure effect is larger and more negative. This is mostly due to the net effect of ageing on education and health. Furthermore, the effect of ageing becomes more important in the second period, where both the productivity and the structure effects become more negative. The key drivers behind this increased negative productivity effect are utilities and health care, whose usage

[9] As we explained above, we are here assuming that there is no general equilibrium effect due to structural trends. If the current trends were to increase the share of sectors whose productivity is growing rapidly, because of endogenous capital deepening or innovation effects the effect we estimate here would be overestimated.

[10] Assuming that we are not "double-counting" the effect of ageing as explained above.

increases with ageing. This is weakly counterbalanced by the fall in the share of educational services, which decreases its contribution.

Table 10: Labour productivity growth decomposition: effect of structural trends towards services and ageing

	Comparison state	1998-2015	2016-2030
Productivity effect			
Agriculture, forestry, fishing and hunting	0.076	-0.026	-0.056
Mining and oil and gas extraction	-0.091	0.021	0.044
Utilities	-0.079	-0.012	-0.020
Construction	-0.041	0.004	0.012
Manufacturing	0.178	-0.017	-0.035
Wholesale	0.139	0.005	0.006
Retail	0.089	-0.004	-0.012
Transportation and warehousing	-0.029	0.002	0.007
Information and cultural industries	0.007	0.000	0.000
FIRE+	-0.185	-0.019	-0.044
Professional, scientific and technical services	0.074	0.001	0.013
Administrative and support services	-0.035	-0.006	-0.022
Education services	-0.054	0.001	0.009
Health care and social assistance	-0.087	-0.015	-0.046
Arts, entertainment and recreation	-0.020	-0.003	-0.007
Accommodation and food services	-0.004	0.000	0.000
Other services	0.010	0.000	0.001
Public administration	0.052	0.002	0.001
Total productivity effect	0	-0.066	-0.149
Structure effect	0	-0.077	-0.091
Total growth gap	0	-0.142	-0.240
Addendum: Difference with base-case level (%)	[redacted]	*2015*	*2030*
Productivity effect		*-1.15*	*-3.29*
Structure effect		*-1.34*	*-2.65*
Total effect		*-2.48*	*-5.86*

At this point, it is important to stress that these results are highly dependant on achieving the productivity growth rates of the recent period. Since 1997, productivity growth has risen in Canada and in particular in the services industries. Faruqui et *al.* (2003) observe, for the services within the business sector, a rebound of 1.6 percentage points between 1988-1996 and 1997-2000. Our data for the total economy suggest a similar trend with a pick-up of around 1.3 for the services sector between 1988-1996 and 1998-2002, as shown in Table 11. Table 11 presents the growth rates for both 1998-2002 and 1988-1996 by industry using two different sources of data. For the recent period, these correspond to growth rates we have used in this paper and were obtained from the ratio of chained-indexed GDP and hours from Cansim's table 383-0010. Unfortunately, these are not available before 1997. We thus rely on a ratio of Laspeyres-indexed GDP and hours from the Labour Force

Statistics Historical Review for the earlier period. If we had used the second dataset for the entire period, we would have observed an even stronger pick-up for the services industries of around 1.6 and no pick-up in the goods-producing industries. Using our most recent, and more appropriate, data source, productivity growth is still, since 1998, higher for goods-producing industries than for services but the gap has narrowed. Seven out of the thirteen services industries had a pick-up in productivity growth above 1.5 percentage points. Although present, the productivity growth improvement is less obvious in goods-producing industries. Thus, our results are highly dependant on the impressive productivity growth experienced by many services industries over the recent period.

Table 11: Average annual labour productivity growth rates by industry

Sectors	1998-2002	1988-1996	Difference
Good-producing sectors	2.61[(1)]	1.67	0.94
Agriculture, forestry, fishing and hunting	5.06	2.85[†]	2.21
Mining and oil and gas extraction	-0.11	2.85[†]	-2.96
Utilities	-0.66	0.19	-0.85
Construction	1.18	-0.62	1.80
Manufacturing	2.95	2.14	0.81
Service-producing sectors	1.96[(1)]	0.68	1.28
High-productivity growth sectors	3.33[(1)]	0.79	2.54
Wholesale	4.62	1.50[*]	3.11
Professional, scientific and technical services	3.81	-1.11	4.92
Retail	3.67	1.50[*]	2.17
Public administration	2.87	1.16	1.71
Other services	2.39	2.05	0.35
Information and cultural industries	2.17	1.35[*]	0.82
Low-productivity growth sectors	1.04[(1)]	0.39	0.65
Transportation and warehousing	1.38	2.13	-0.74
FIRE+	1.02	1.61	-0.59
Administrative and support services	0.20	-1.34	1.54
Education services	0.89	-1.03	1.92
Health care and social assistance	0.57	-0.83	1.40
Arts, entertainment and recreation	-0.29	1.35[*]	-1.65
Accommodation and food services	1.83	-0.95	2.77

Note: [†], [*], [+] identify sectors for which productivity growth was estimated jointly over the 1988-1996 due to the absence of data by separate industry.
[(1)]: Growth rate estimated for 1998-2001 only.

What would then be the impact of the structural shifts we identified above if productivity growth for the services industries were to fall back to that of the 1988-1996 period? Combining ageing and structural trends leads to severe reductions in aggregate productivity growth, to 1.09 per cent for 1998-2015 and 0.95 per cent for 2016-2030. If instead of using our old base-case, we compare these scenario results to a new base-case where industry growth rates are now that of the average 1988-1996 for services, the combined effect of ageing and of a shift towards services reduces annual productivity growth to 0.95 as compared to 1.24 in the base-case. This reduction translates into a 6.6 per cent difference in the 2030 productivity level, a larger reduction than the 5.9 per cent observed with 1998-2001 productivity growth rates. Thus, Canada's capacity to continue to achieve high productivity growth

resides crucially in the productivity growth performance of highly demanded sectors, such as services. The results of all scenarios presented until now are summarized in Table 12.

Table 12: The impact of ageing and structural shifts towards services on base-case productivity level and growth

	Productivity growth		Productivity level	
	1998-2015	2016-2030	2015	2030
Scenarios	*Percentage points compared to base-case*		*Percentage difference with base-case*	
Ageing	-0.03	-0.04	-0.47	-1.08
Productivity	-0.02	-0.02	-0.35	-0.69
Structure	-0.01	-0.02	-0.12	-0.39
Trends	-0.14	-0.22	-2.39	-5.54
Productivity	-0.07	-0.14	-1.15	-3.20
Structure	-0.07	-0.08	-1.25	-2.41
Ageing and Trends	-0.14	-0.24	-2.48	-5.86
Productivity	-0.07	-0.15	-1.15	-3.29
Structure	-0.08	-0.09	-1.34	-2.65
Ageing and Trends (past growth rates)	-0.88	-1.02	-14.50	-26.48
Productivity	-0.81	-0.93	-13.3	-24.46
Structure	-0.08	-0.09	-1.34	-2.65
Base-case levels	1.98	1.98	47.02	63.05

How could we reverse the projected slow-down in productivity growth due to ageing and structural trends towards services? First, we could attempt to increase the productivity growth of the key sector in these simulations: health care. To annihilate the effect of ageing alone, we would require a growth rate in this sector of 1.07 per cent per year over the entire period. However, if we include the additional pressures on health care that are unrelated to ageing and identified as a structural trend, we find that this sector would have to achieve productivity growth of 2.83 per cent per annum for the entire period. These growth rates are far from being unachievable but are rarely seen in publicly offered services such as health care. For example, in Table 11, we observe that health care services had negative productivity growth over the 1988-1996 period and a mere 0.57 per cent for 1998-2002. Only four out of 13 services industries attained growth rates above 2.8 per cent in Table 11 and that, only over 1998-2002. These results nevertheless highlight the critical impact that productivity improvements in health care or other services industries could have on diminishing the potential impact of ageing on aggregate productivity growth.

On the other hand, what could reduce the impact of the structural trends we identified? We observed that these trends tend to favour services over goods-producing industries. However, historically, productivity growth rates in some services industries have been quite low. How large would productivity growth rates have to be for all services industries in order to cancel the effect of this trend? If we could only achieve a productivity growth rate of 1.33 per cent per year in Table 11's low productivity growth industries, the entire gap due to our structural trends and ageing would vanish. This is only around 0.3 percentage points higher than their 1998-2002 performance. Similarly, we would need all services to achieve a common productivity growth rate of 2.09 to annihilate the deficit we projected above. If this

appears to be difficult for some low-growth industries, it is barely above the average growth for the whole services sector over 1998-2002. However, over the 1988-1996 period, only one service industry, transportation and warehousing, achieved a rate of productivity growth higher than this. Thus, increasing and maintaining the current high productivity growth in the services industries will be crucial for alleviating the impact of future structural shifts.

5. Conclusion

This paper suggests a methodology for estimating the potential effect of ageing and structural shifts towards services on aggregate labor productivity through changes in the industrial structure, using household consumption data and Input-Output tables. We find that the consumption patterns of the elderly differ substantially from those of middle-aged cohorts and that this translates into differences in key industries for each age group. However, we also find that the impact is small in terms of future industrial structure, with the exception of education services, health care and other services. Nevertheless, these limited changes in structure could potentially reduce the aggregate productivity level by about 1 per cent in 2030. However, this paper also highlights the potential impact of a continued growing importance of low-productivity growth and level service sectors. Introducing these trends towards services reduces future labour productivity growth significantly. The projected productivity level in 2030 is now 5 per cent below that of the base-case. Although these results are sensitive to baseline assumptions regarding productivity growth and structural trends, we believe they represent lower-bound estimates of the potential impact of ageing and structural trends towards services on productivity. Moreover, given that the rebound in the productivity growth of some key service sectors is relatively recent, we also emphasize how important maintaining these high levels of growth will be for future aggregate productivity growth.

These conclusions are subject to some caveats. They are, first of all, sensitive to industrial growth hypotheses. However, they could also be affected by other factors. First, some might question the appropriateness of SPSD/M as a data source. As we explained before, we believe this is the only data source that allows for the matching required in this study. Nevertheless, we also tested the validity of our results using a more traditional data set such as the Survey of Household Spending (SHS) or in its previous version, Family Expenditure Survey (FAMEX). Preliminary analysis suggests that these data sets provide similar consumption patterns by age once we account for differences in methodology.

Some might also be concerned about cohort effects. In this exercise, we are imposing today's elderly consumption patterns on the next generations. If there are strong cohort effects, this would provide erroneous results. The absence of consumption panel data for Canada prevents us from testing whether this hypothesis is inaccurate. However, our preliminary analysis using various waves of the SHS and FAMEX indicate that there were no significant changes in consumption patterns by age over time, once differences in surveys' methodologies were considered. Nevertheless, it is currently impossible to determine whether the baby boomers will resemble their parents once they retire or they will be very different. Some have hypothesized that the consumption of the new generation of the elderly might even be

more concentrated on personal and health services, as this new generation of elderly might not have the family support network the current generation has.

We should also explore whether a more disaggregated industry data, in particular for the manufacturing sector, could change our conclusions. This might be important given the high variability in productivity growth performances by sub-sectors and the differences in demand patterns. We decided to analyze at the two-digit level because we felt more confident regarding our allocation of larger sectors' output by age. Nevertheless, this issue should be pursued further.

Our results are also sensitive to the accuracy of productivity growth rates by industry but also to demographic projections. It could be interesting to study how our results would be altered if the immigration and ageing forecasts were modified.

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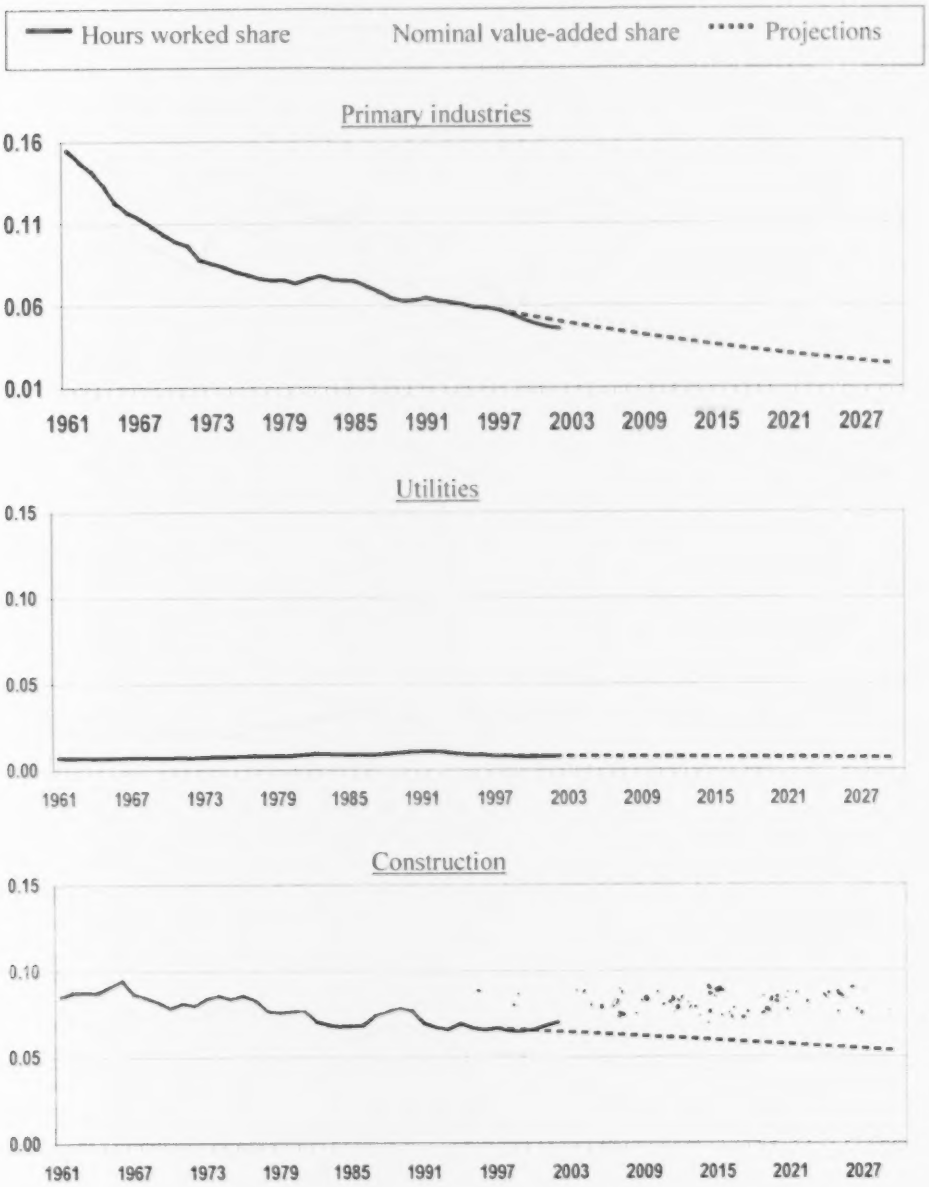
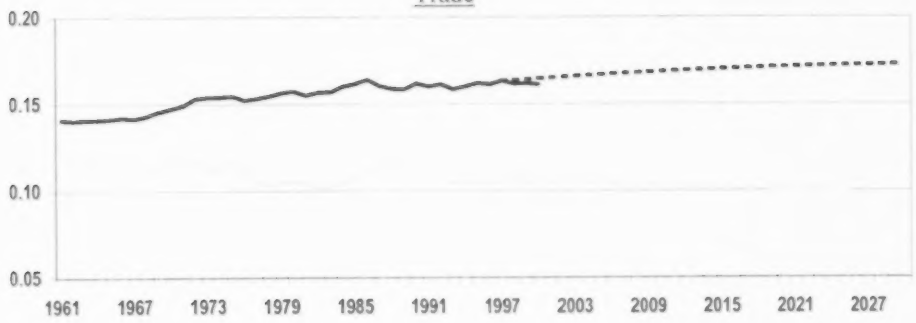
Appendix A: Actual and projected shares by industry, 1961-2030



Trade



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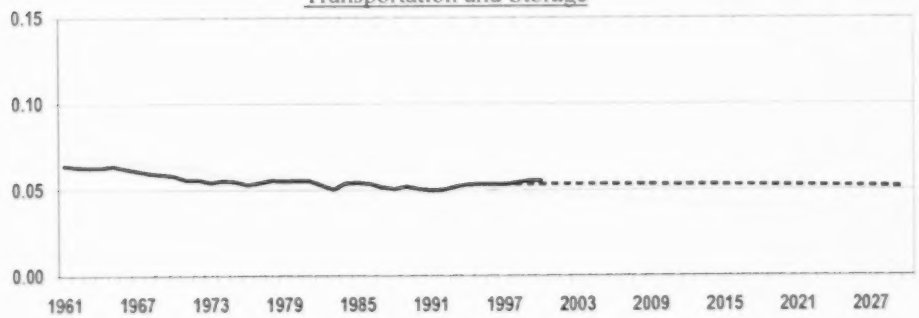
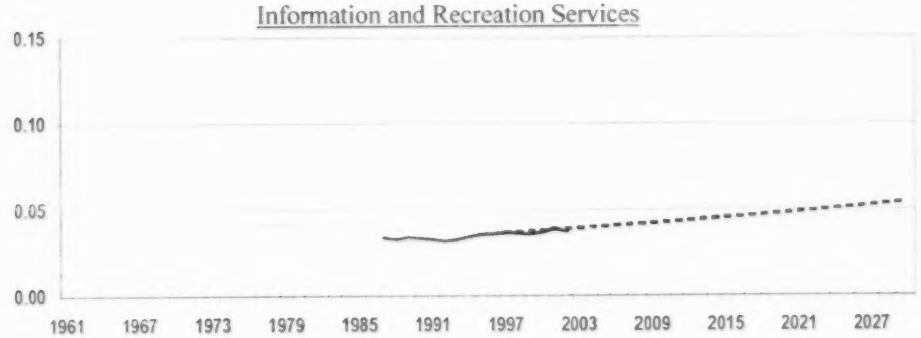
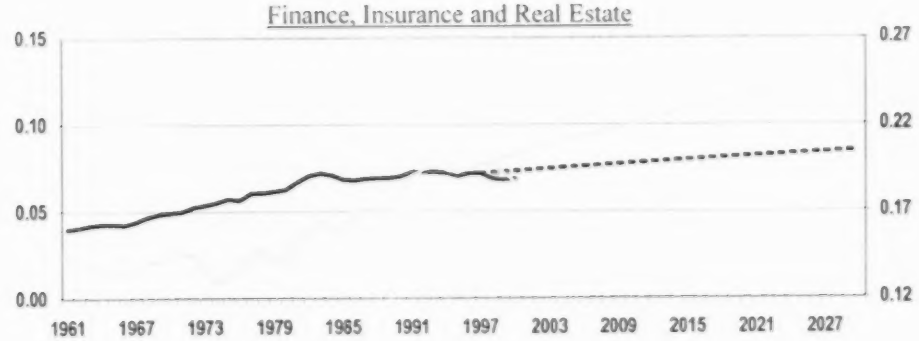


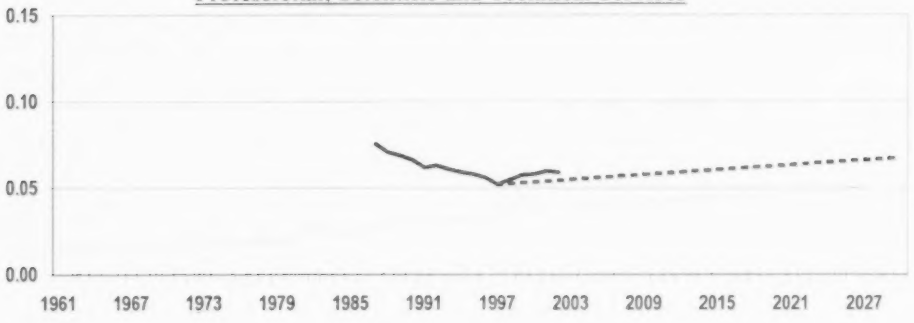
Information and Recreation Services



Finance, Insurance and Real Estate



Professional, Scientific and Technical Services



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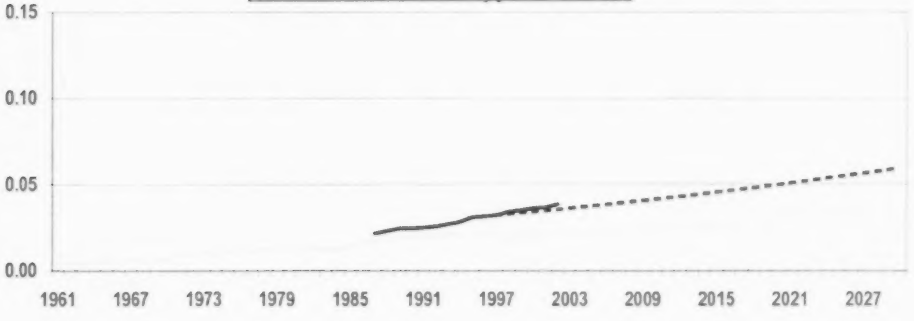
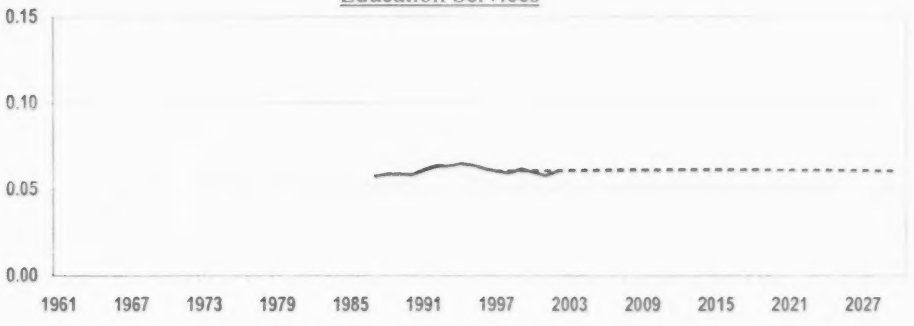
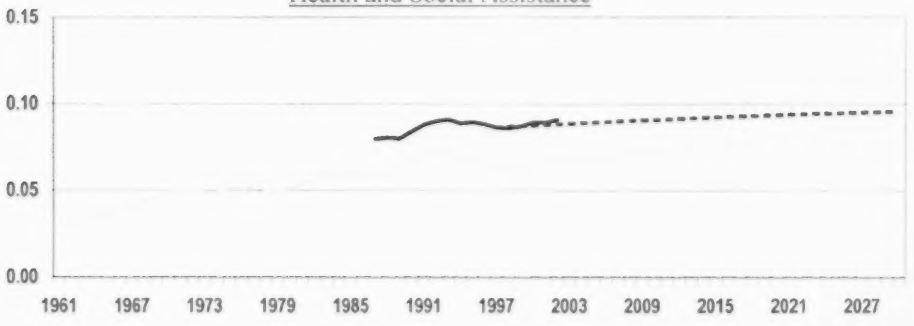
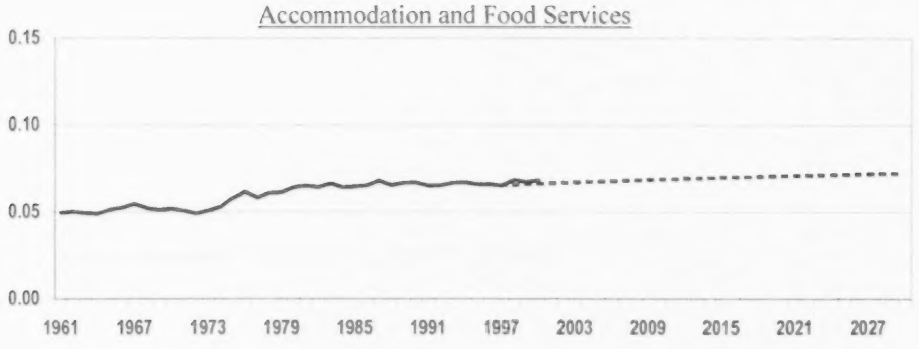


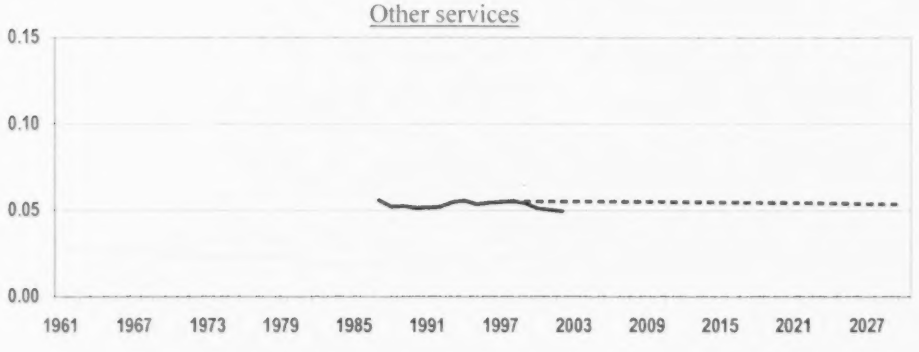
Education Services



Health and Social Assistance




Accommodation and Food Services
0.15
0.10
0.05
0.00
1961
1967
1973
1979
1985
1991
1997
2003
2009
2015
2021
2027


Other services
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1961
1967
1973
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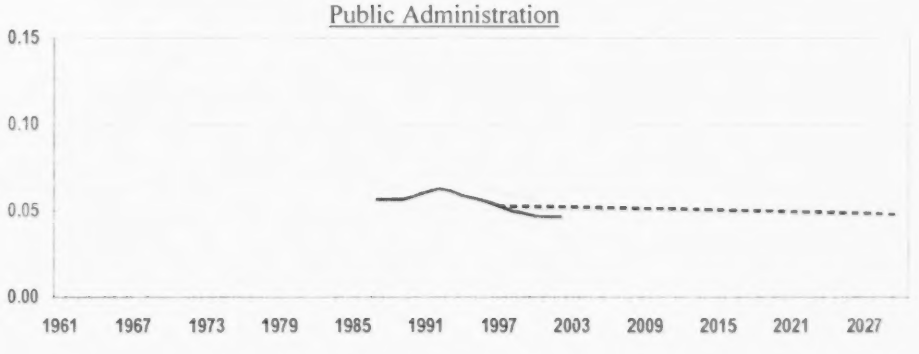
2015
2021
2027


Public Administration
0.15
0.10
0.05
0.00
1961
1967
1973
1979
1985
1991
1997
2003
2009
2015
2021
2027

Appendix B: Personal expenditure categories and their included commodities

Cat.	Name	Includes
0	Food and non-alcoholic beverages	• Food and non-alcoholic beverages • Imputed food
1	Alcoholic beverages bought in stores	
2	Tobacco products	
3	Men's and boys' clothing	
4	Men's clothing repairs and alterations	
5	Women's, girl's and infant's clothing	
6	Women's clothing repair and alterations	
7	Footwear	
8	Footwear repairs	
9	Gross imputed rent	
10	Gross paid rent	• Gross paid rent • Furniture and appliance rentals • Janitorial services
11	Other shelter expenses	• Water charges • Imputed lodging • Paid lodging (excluding universities) • Lodging in universities • Property insurance
12	Electricity	
13	Natural Gas	
14	Other fuels	
15	Furniture, carpets and other floor coverings	• Furniture • Floor coverings
16	Upholstery and furniture repairs	
17	Household appliances	• Refrigerators and freezers • Washers and dryers • Stoves, ranges and microwave ovens • Other major appliances • Small electrical appliances • Garden tools and equipment
18	Household equipment repairs	
19	Semi-durable household furnishings	• Notions and smallware • Piece goods • Household textiles and furnishings • China, glassware and crockery • Lamps, fixture and accessories • Silverware and flatware • Hardware
20	Non-durable household supplies	• Pet food • Soaps and other cleaning supplies • Other household supplies • Flowers and plants

21	Domestic and child care services	• Domestic services • Child care, in the home • Child care, outside the home
22	Other household services	• Laundry and dry cleaning • Pet care • Miscellaneous household services
23	Medical care	• Medical care, dental care and the like • Special care facilities • Other health care
24	Hospital care and the like	
25	Other medical care expenses	
26	Drugs and pharmaceutical products	
27	New and used (net) motor vehicles	• New automobiles • Used motor vehicles (net) • New trucks and vans
28	Motor vehicle parts and accessories	
29	Motor vehicle maintenance and repairs	
30	Motor fuels and lubricants	
31	Other auto related services	• Bridge and highway tolls • Auto insurance • Parking • Driving licenses, lessons and tests • Motor vehicle renting
32	Purchased transportation	• Commissions paid to tour operators • Urban transit • Railway transport • Interurban bus • Air transport • Water transport • Taxis • Moving and storage
33	Communications	• Telecommunications • Postal services
34	Recreation, sporting and camping equipment	• Bicycles and motorcycles • Radios, sound systems and accessories • TV sets, video equipment and accessories • Boats, aircraft and accessories • Cameras and accessories • Sporting and camping equipment • Office machines and computer equipment • Musical instruments and supplies • Trailers
35	Recreation equipment repairs and rentals	

36	Reading and entertainment supplies	• Toys, games and hobby supplies • Films and other photographic supplies • Newspapers, books, magazines and stationery • Pets and supplies
37	Recreational services	• Games of chance • Pari-mutuel betting • Other recreational services • Cable television and pay television • Cinemas • Photographic services
38	Education and cultural services	• University fees • Private school fees • Other educational and cultural services
39	Watches and jewelry	
40	Watches and jewelry repairs	
41	Luggage, leather goods and other personal effects	
42	Cosmetics and toiletries	
43	Personal care services	• Hairstyling for men and women • Other personal care • Undertaking and other funeral services
44	Restaurants and accommodation services	• Meals outside the home • Alcoholic beverages consumed in licensed premises • Accommodation services • Board paid
45	Financial and legal services	• Stock and bond commissions • Financial intermediaries, implicit loan charges • Credit unions, implicit deposit charges • Life insurance • Financial intermediaries, explicit charges • Financial intermediaries, implicit deposit charges • Credit unions, explicit charges • Trusteed pension funds • Credit unions, implicit loan charges • Mutual funds • Legal, accounting and other services
46	Operating expenses of non-profit organizations	• Welfare and charitable organizations • Religious organizations • Trade unions • Political parties • Indian bands and Inuit

Appendix C: Matching consumption to industrial structure: an example

Let us assume that we have the following economy with two industries, I1 and I2, and two age groups, young and old:

	Use Matrix		Final Demand	
	I1	I2	Young (20 persons)	Old (10 persons)
I1	20	40	20	20
I2	40	10	10	20
VA	40	30		
Total	100	80	30	40

First, we establish how the final demand output of each industry is divided between each age group. Here, half of I1's output is consumed by the young and half by the old. On the other hand, one-third of industry 2's output is consumed by the young and two-third by the old. The next table summarizes these results.

	Final Demand			
	Young (Quantities)	Old (Quantities)	Young (Proportion)	Old (Proportion)
I1	20	20	0.5	0.5
I2	10	20	0.33	0.67

From this, we allocate each industry's inputs by age group, assuming that the required inputs for the output consumed by each age group do not vary by age group. Thus, since I1's output is consumed in equal proportion by the young and the old, its inputs (from I1 and I2) will be divided equally between the two groups. However, because one-third of industry I2's output is consumed by the young and two-thirds by the old, its inputs (from I1 and I2) will be allocated in the same proportions. Thus, we will distribute I1's inputs such that half is given to the young, and half to the old. On the other hand, we allocate the 40 units of I1 used by I2 as inputs as 13.33 units to the young and 26.67 units to the old and the 10 units of I2 as 3.33 units to the young and 6.67 units to the old. A summary is presented here:

	Use Matrix		Use Matrix			
	I1	I2	I1		I2	
			Young	Old	Young	Old
			proportions			
I1	20	40	0.5	0.5	0.33	0.67
I2	40	10	0.5	0.5	0.33	0.67
			quantities			
I1	20	40	10	10	13.33	26.67
I2	40	10	20	20	3.33	6.67

Once intermediate inputs are allocated by age, we can now divide total output by summing the quantities given to each age group in the Final Demand table and the Use Matrix, as shown in the following table:

	Use Matrix				Final Demand		Total Output	
	I1		I2		Young	Old	Young	Old
	Young	Old	Young	Old				
I1	10	10	13.33	26.67	20	20	43.33	56.67
I2	20	20	3.33	6.67	10	20	33.33	46.67

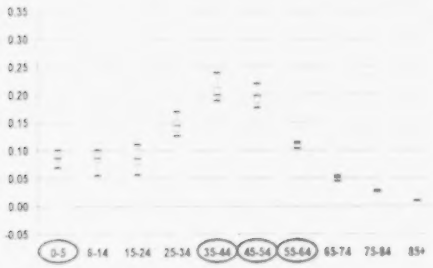
Then, we can either use a proportion of total output to impose this division on other measures or convert the figures in per capita. The next table offers both alternatives:

	Total Output			
	Proportion		Per capita	
	Young	Old	Young	Old
I1	0.43	0.57	2.17	5.67
I2	0.42	0.58	1.67	4.67

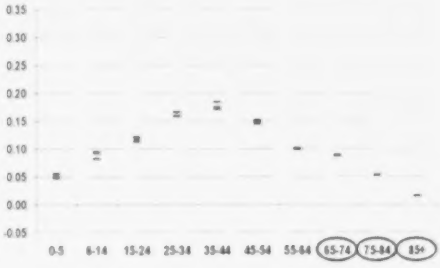
Appendix D: Consumption and production by age group, 1997

Figure D1: Consumption shares by age group, by commodity

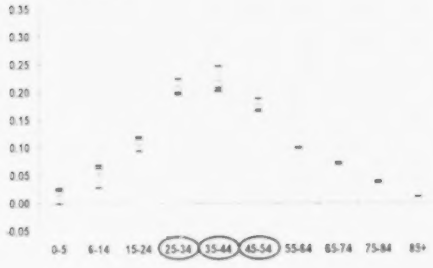
1. Gross imputed rent



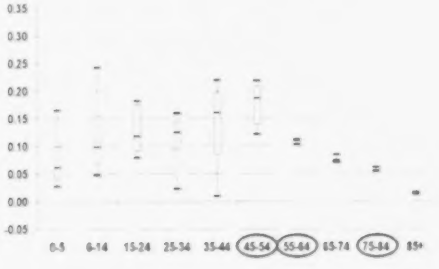
2. Food and non-alcoholic beverages



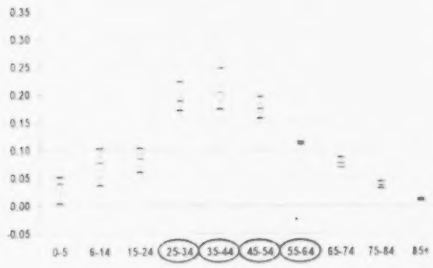
3. Restaurants and accommodation services



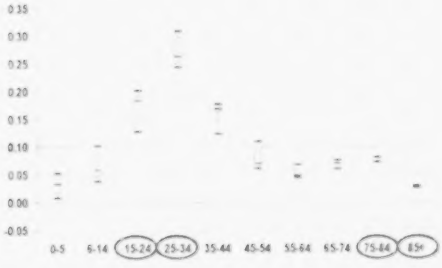
4. Financial and legal services



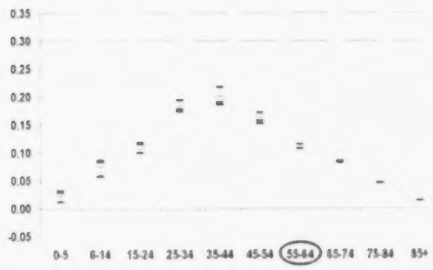
5. New and used motor vehicles



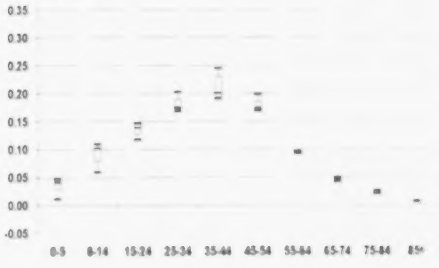
6. Gross paid rent



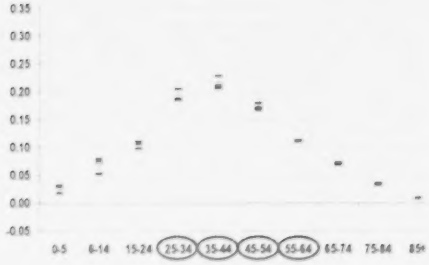
7. Recreational services



8. Recreation, sporting and camping equipment

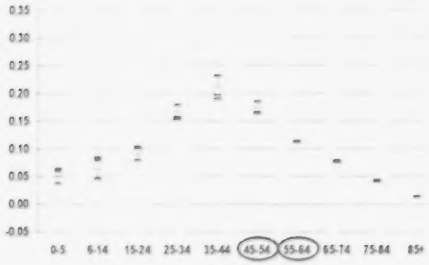


9. Motor fuels and lubricants



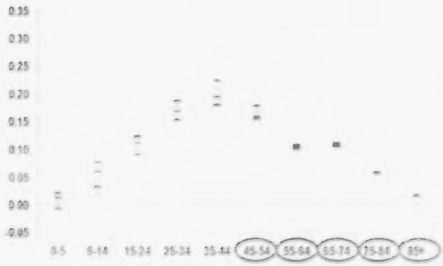
10. Women's, girl's and infant's clothing

11. Semi-durable household furnishings



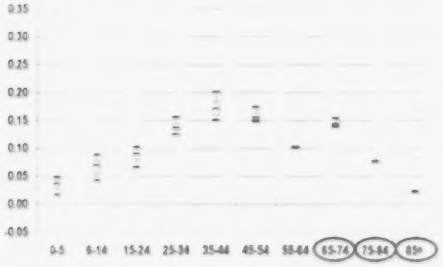
12. Medical care

13. Purchased transportation

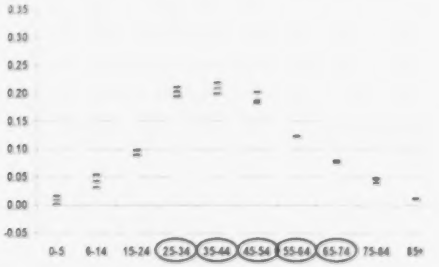


14. Electricity

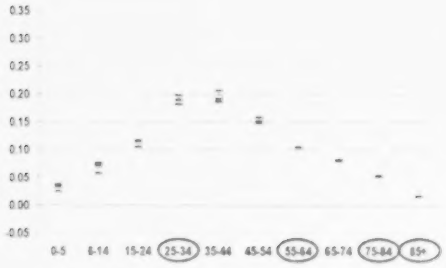
15. Operating expenses of non-profit organizations



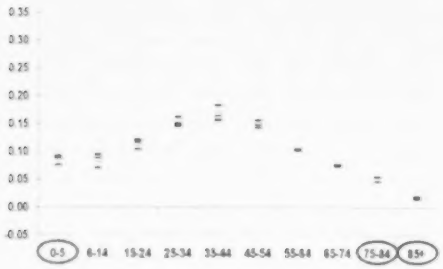
16. Alcoholic beverages bought in stores



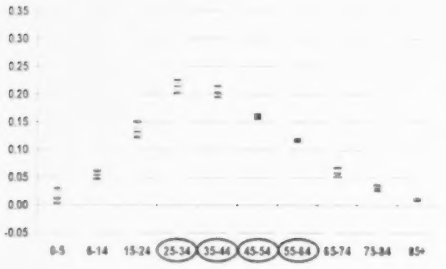
17. Communications



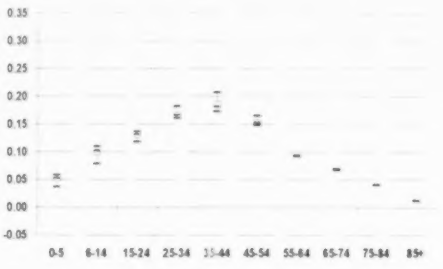
18. Non-durable household supplies



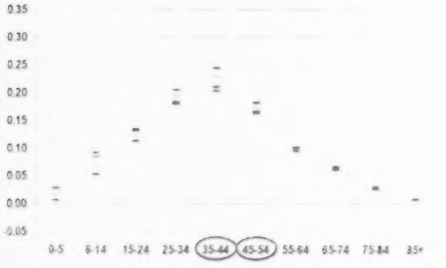
19. Tobacco products



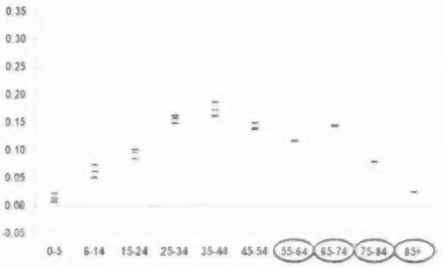
20. Reading and entertainment supplies



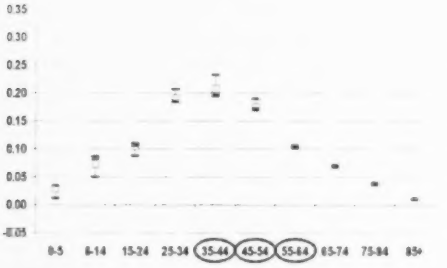
21. Men's and boys' clothing



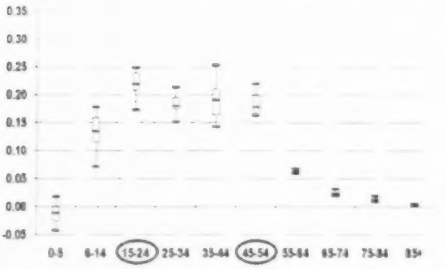
22. Drugs and pharmaceutical products



23. Other auto related services

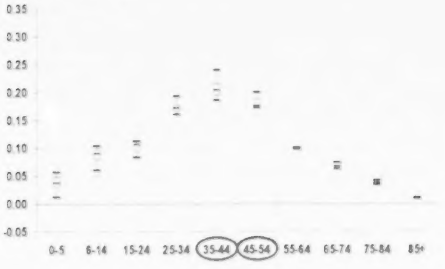


24. Educational and cultural services

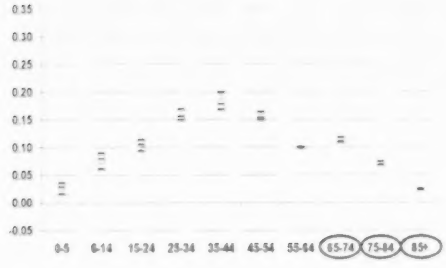


25. Household appliances

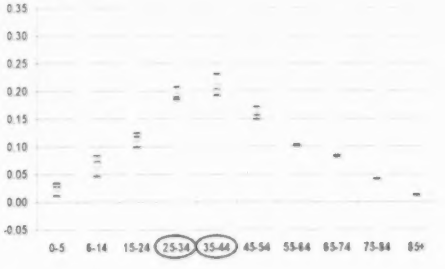
26. Furniture, carpets and other floor coverings



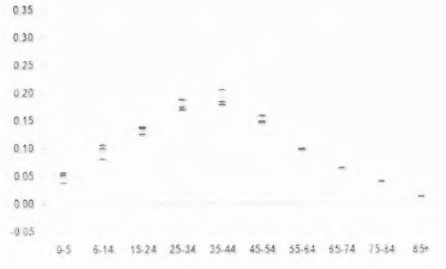
27. Personal care services



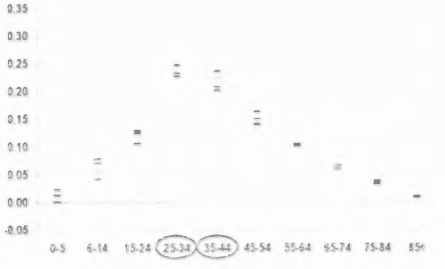
28. Motor vehicle maintenance and repairs



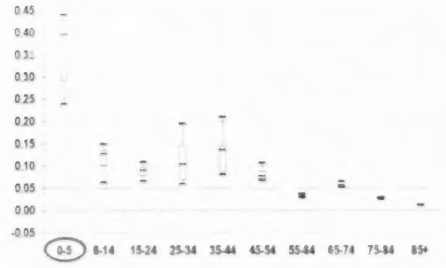
29. Cosmetics and toiletries



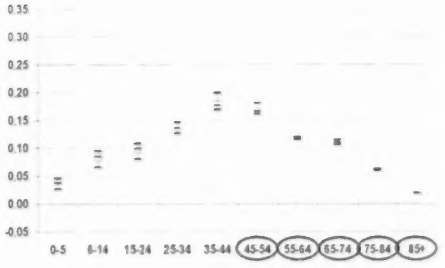
30. Motor vehicle parts and accessories



31. Domestic and child care services

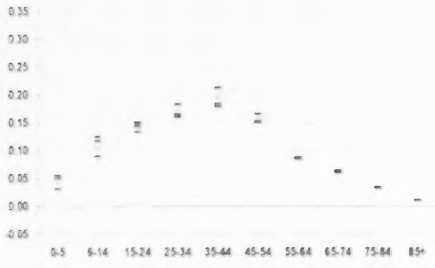


32. Other shelter expenses

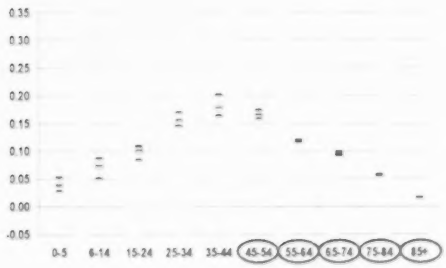


33. Natural Gas

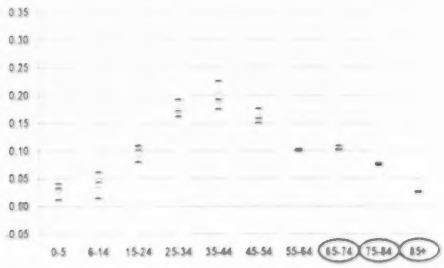
34. Footwear



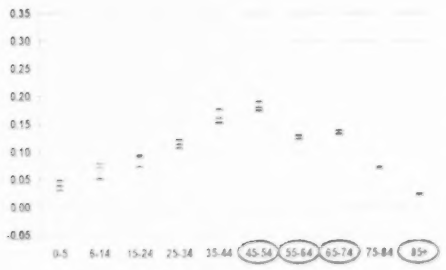
35. Other medical expenses



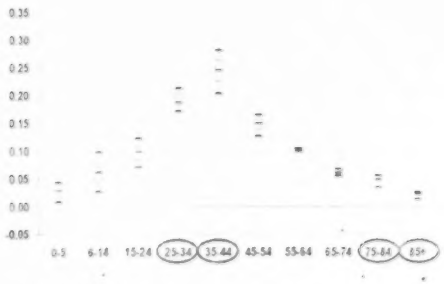
36. Other household services



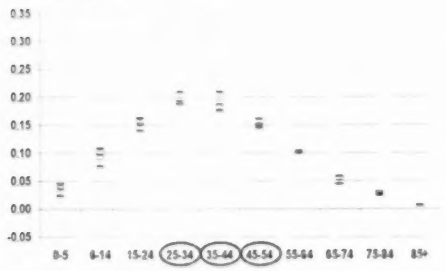
37. Other fuels



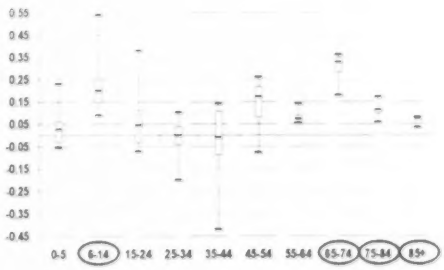
38. Watches and jewelry



39. Recreation equipment repairs and rentals

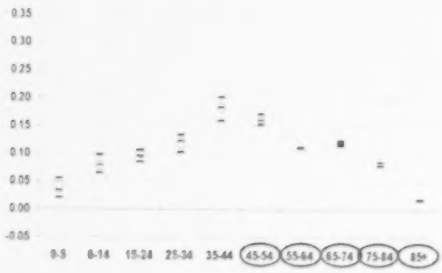


40. Hospital care and the like

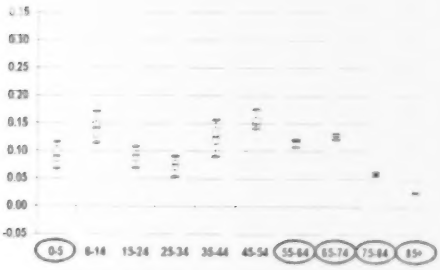


41. Luggage, leather goods and other personal effects

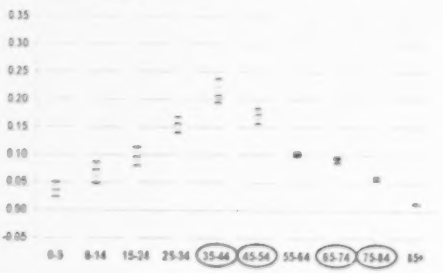
42. Household equipment repairs



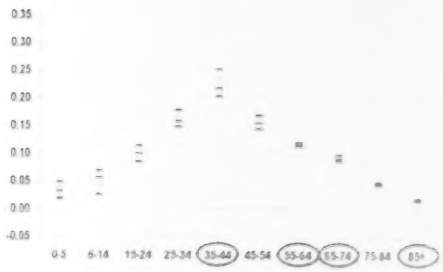
43. Upholstery and furniture repairs



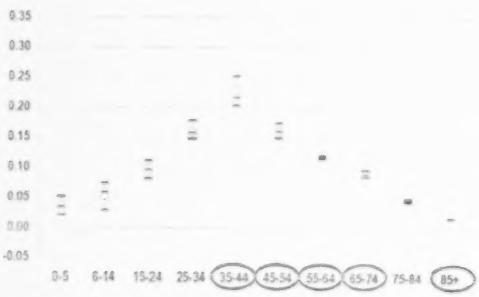
44. Women's clothing repair and alterations



45. Watches and jewelry repairs



46. Footwear repairs



47. Men's clothing repairs and alterations

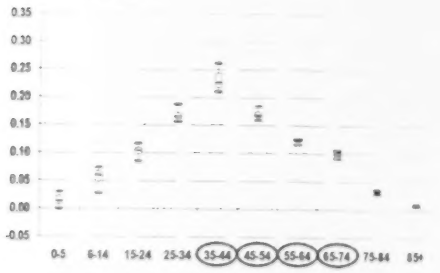


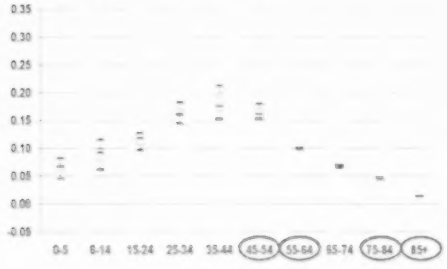
Table D1: Median proportion of total commodity consumption by age group, 1997

	0-5	6-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+
Food and non-alcoholic beverages	5.39	9.22	11.85	15.90	17.43	14.68	10.04	8.79	5.24	1.52
Alcoholic beverages bought in stores	0.88	4.27	9.67	20.15	20.87	18.60	12.27	7.77	4.44	1.09
Tobacco products	1.25	5.42	13.18	21.44	20.24	15.99	11.72	5.75	3.05	0.98
Men's and boys' clothing	2.68	8.44	13.08	18.33	21.01	16.56	9.92	6.43	2.79	0.71
Men's clothing repairs and alterations	1.28	5.97	10.38	16.42	22.57	16.73	12.32	9.88	3.19	0.76
Women's, girl's and infant's clothing	5.26	9.43	11.67	15.57	18.09	16.37	9.70	7.89	4.52	1.33
Women's clothing repairs and alterations	3.56	7.17	9.52	15.54	20.73	17.30	10.18	9.20	5.54	1.19
Footwear	4.87	11.57	14.30	16.43	18.34	15.20	8.54	6.16	3.29	1.00
Footwear repairs	3.37	5.78	9.61	15.75	21.68	16.04	11.82	8.91	4.44	1.61
Gross imputed rent	8.69	8.69	8.59	14.50	19.95	19.81	11.21	5.02	2.72	0.90
Gross paid rent	3.33	5.79	18.31	26.30	16.84	6.99	4.77	7.03	7.28	2.73
Other shelter expenses	3.71	8.42	9.85	13.56	17.55	16.54	11.66	10.84	5.95	1.81
Electricity	5.13	8.48	10.31	14.56	17.26	14.83	11.88	10.20	5.73	1.70
Natural gas	4.23	8.00	8.66	13.11	16.21	15.20	12.26	12.90	7.22	2.29
Other fuels	3.91	7.15	8.96	11.29	16.02	17.90	12.79	13.26	7.07	2.16
Furniture, carpets and other floor coverings	3.73	9.03	10.64	17.15	20.37	17.54	9.89	6.66	3.59	0.93
Upholstery and furniture repairs	8.96	14.07	9.14	7.51	12.50	14.85	11.78	12.63	5.71	2.49
Household appliances	3.45	6.88	8.40	17.26	19.07	17.63	12.03	8.96	4.69	1.46
Household equipment repairs	3.36	7.91	9.51	12.21	18.31	16.00	11.02	11.82	7.91	1.75
Semi-durable household furnishings	5.97	7.85	9.99	15.65	19.59	16.55	11.22	7.74	4.10	1.32
Non-durable household supplies	8.77	8.83	11.62	14.98	16.39	14.77	10.24	7.44	5.35	1.84
Domestic and child care services	39.59	12.58	8.90	10.27	13.46	7.58	3.09	5.41	2.50	0.99
Other household services	3.14	4.31	10.07	17.14	19.17	15.79	10.07	10.20	7.61	2.55
Medical care	4.11	10.38	12.14	11.31	14.45	13.00	10.83	12.46	7.36	3.88
Hospital care and the like	2.61	19.79	4.26	-0.23	-1.03	17.10	7.20	32.58	11.16	7.23
Other medical care expenses	3.86	7.41	10.16	15.59	17.91	16.58	11.71	9.50	5.51	1.58
Drugs and pharmaceutical products	1.24	6.11	9.49	15.63	17.18	13.99	11.71	14.38	7.89	2.50
New and used (net) motor vehicles	3.92	7.70	8.42	18.82	20.41	17.46	11.30	7.66	3.57	1.06
Motor vehicle parts and accessories	1.17	7.01	12.32	23.16	20.72	14.95	10.19	6.29	3.33	0.84
Motor vehicle maintenance and repairs	2.71	7.25	11.69	18.87	20.30	15.59	10.17	8.25	4.11	1.13
Motor fuels and lubricants	2.85	7.40	10.53	18.68	21.07	17.03	11.09	7.09	3.49	0.87
Other auto related services	3.31	8.08	10.53	18.57	19.89	17.33	10.36	7.03	3.82	1.04
Purchased transportation	1.34	6.06	11.24	16.96	19.50	15.93	10.50	10.79	5.67	1.69
Communications	3.33	7.02	11.38	18.96	19.15	15.07	10.40	7.99	5.17	1.59
Recreation, sporting and camping equipment	4.03	10.14	13.86	17.41	20.02	17.34	9.44	4.64	2.19	0.55
Recreation equipment repairs and rentals	3.58	9.66	15.10	19.18	18.62	14.99	10.22	5.03	2.56	0.51
Reading and entertainment supplies	5.24	10.19	13.13	16.63	18.18	15.28	9.28	6.86	4.07	1.18
Recreational services	2.86	8.28	11.50	17.66	18.98	15.68	10.72	8.37	4.56	1.37
Education and cultural services	-1.21	13.40	21.90	17.99	19.08	17.80	6.23	2.29	1.29	0.22
Watches and jewelry	2.90	6.16	9.84	18.76	24.54	14.96	10.00	6.00	4.79	2.12
Watches and jewelry repairs	3.18	5.67	10.06	15.91	21.86	15.53	11.83	9.11	4.54	1.70
Luggage, leather goods and other personal effects	3.31	7.40	11.38	18.68	19.89	15.59	10.36	7.09	3.82	1.06
Cosmetics and toiletries	4.96	9.79	13.38	17.34	18.31	14.84	9.74	6.37	3.88	1.17
Personal care services	2.83	7.90	10.45	15.48	17.74	15.34	9.84	10.98	6.80	2.22
Restaurants and accommodation services	2.24	6.28	11.61	19.97	20.78	16.84	9.93	7.17	3.88	1.11
Financial and legal services	6.11	9.82	11.73	12.47	16.02	18.66	10.97	7.36	5.50	1.30
Operating expenses of non-profit organizations	3.65	6.92	8.99	13.58	17.07	15.47	10.12	14.21	7.67	2.25
Aggregate consumption	5.56	9.26	12.09	16.30	17.55	15.64	10.09	7.67	4.45	1.37

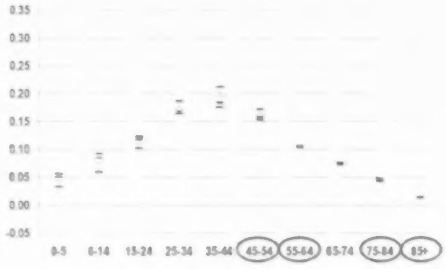
[ ] : identifies sectors with shares above that of their population share

Figure D2: Production Share by Age Group, by NAICS industry

1. Finance, insurance, real estate and management of companies

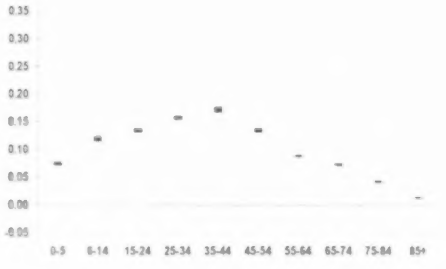


2. Manufacturing



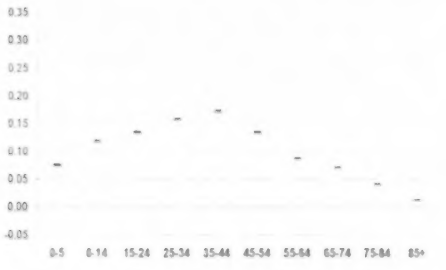
3. Health care and social assistance

4. Public administration

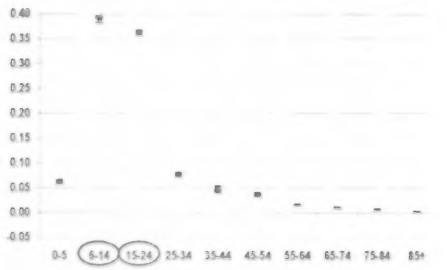


5. Wholesale trade

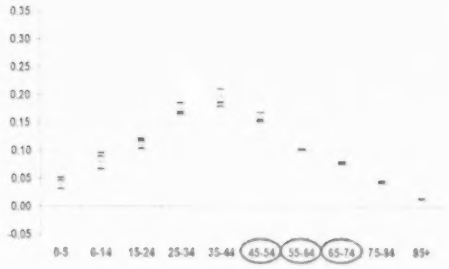
6. Construction



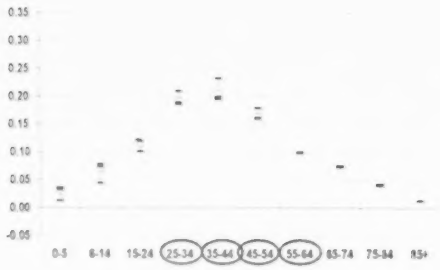
7. Education services



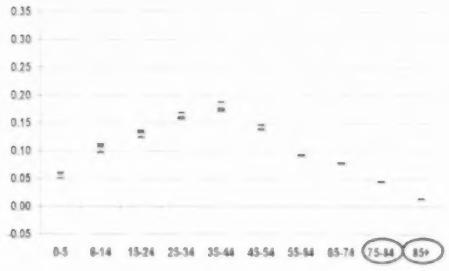
8. Retail trade



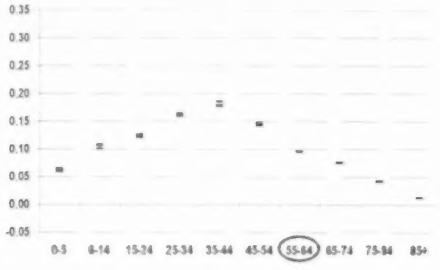
9. Transportation and warehousing



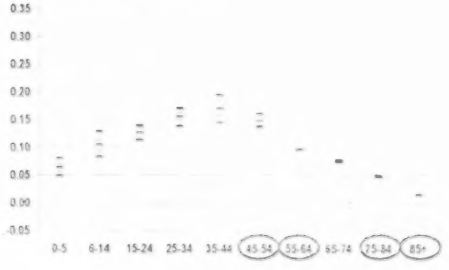
10. Mining



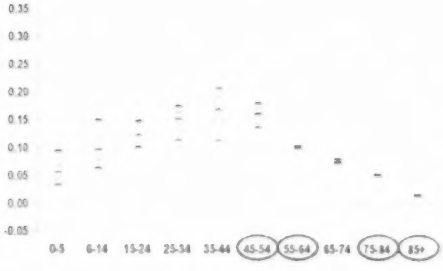
11. Professional, scientific and technical services



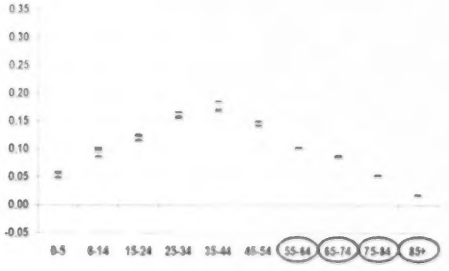
12. Information and cultural industries



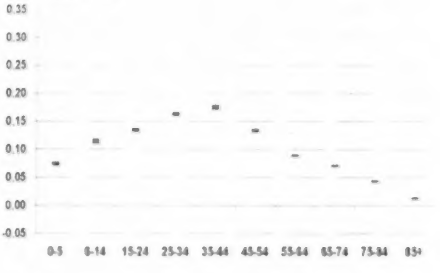
13. Utilities



14. Agriculture, fishing, hunting and logging

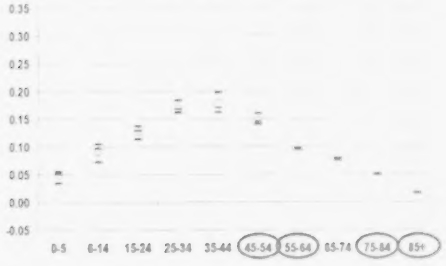


15. Accommodations and restaurants



16. Other services

17. Administrative and support, waste management and remediation serv.



18. Arts, entertainment and recreation

Table D2: Median proportion of total industry production by age group, 1997

	0-5	6-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+
Agriculture, forestry, fishing, hunting and trapping	7.32	11.51	13.30	16.20	17.28	13.23	8.78	6.98	4.16	1.24
Mining	6.28	10.63	12.48	16.01	17.84	14.32	9.54	7.53	4.17	1.23
Utilities	5.62	9.77	12.24	15.67	17.06	14.18	10.11	8.59	5.15	1.64
Construction	7.51	11.88	13.43	15.67	17.10	13.30	8.71	7.06	4.07	1.25
Manufacturing	5.02	8.50	11.76	16.85	18.38	15.82	10.40	7.43	4.50	1.43
Wholesale Trade	5.61	9.42	12.36	16.51	17.99	15.07	9.91	7.44	4.48	1.43
Retail Trade	4.60	8.96	11.63	16.92	18.62	15.61	10.16	7.76	4.32	1.29
Transportation and warehousing	5.82	10.69	13.23	16.08	17.61	13.92	9.18	7.75	4.41	1.33
Information and cultural industries	5.62	9.73	12.31	15.20	16.89	16.08	10.16	7.48	5.00	1.43
FIRE and management of companies	6.66	9.19	11.81	16.03	17.61	16.10	9.92	6.68	4.46	1.39
Professional, scientific and technical services	6.32	10.49	12.65	15.55	17.02	14.85	9.58	7.46	4.64	1.39
Administrative and support services	5.09	9.64	12.88	16.79	17.04	14.57	9.61	7.72	5.01	1.64
Educational services	6.10	38.88	36.25	7.56	4.51	3.37	1.53	0.94	0.55	0.17
Health care services and social assistance	6.37	7.95	10.07	11.50	12.52	10.94	9.21	12.8	11.6	7.07
Arts, entertainment and recreation	2.69	7.53	11.30	17.90	19.16	16.14	10.90	8.18	4.61	1.40
Accommodation and food services	3.15	7.27	11.84	18.94	19.93	16.20	9.81	7.37	4.08	1.23
Other services	5.51	8.60	11.26	15.15	16.94	14.69	9.47	10.1	5.88	1.94
Public administration	7.46	11.89	13.38	15.60	17.02	13.33	8.76	7.19	4.14	1.26
Total industries	6.00	10.69	13.14	15.73	16.85	14.37	9.50	7.39	4.61	1.56

: identifies sectors with shares above that of their population share.